REPUBLIC OF MALI

MINISTRY OF AGRICULTURE

UPDATING FEASIBILITY STUDY ON BAGUINEDA AGRICULTURAL DEVELOPMENT PROJECT

MAIN REPORT

MARCH 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Mali, the Japanese Government decided to conduct a survey on the Baguineda Agricultural Development Project and entrusted the survey to the Japan International Cooperation Agency (JICA). JICA sent to Mali a survey team headed by Mr.Tetsuo Yaguchi, Department Chief of the First Irrigation & Drainage Engineering Department, Nippon Koei Co., Ltd., from October to November, 1985.

The team exchanged views with the officials concerned of the Government of the Republic of Mali and conducted a field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Republic of Mali for their close cooperation extended to the team.

March, 1986

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

UPDATING FEASIBILITY STUDY
ON
BAGUINEDA AGRICULTURAL DEVELOPMENT PROJECT

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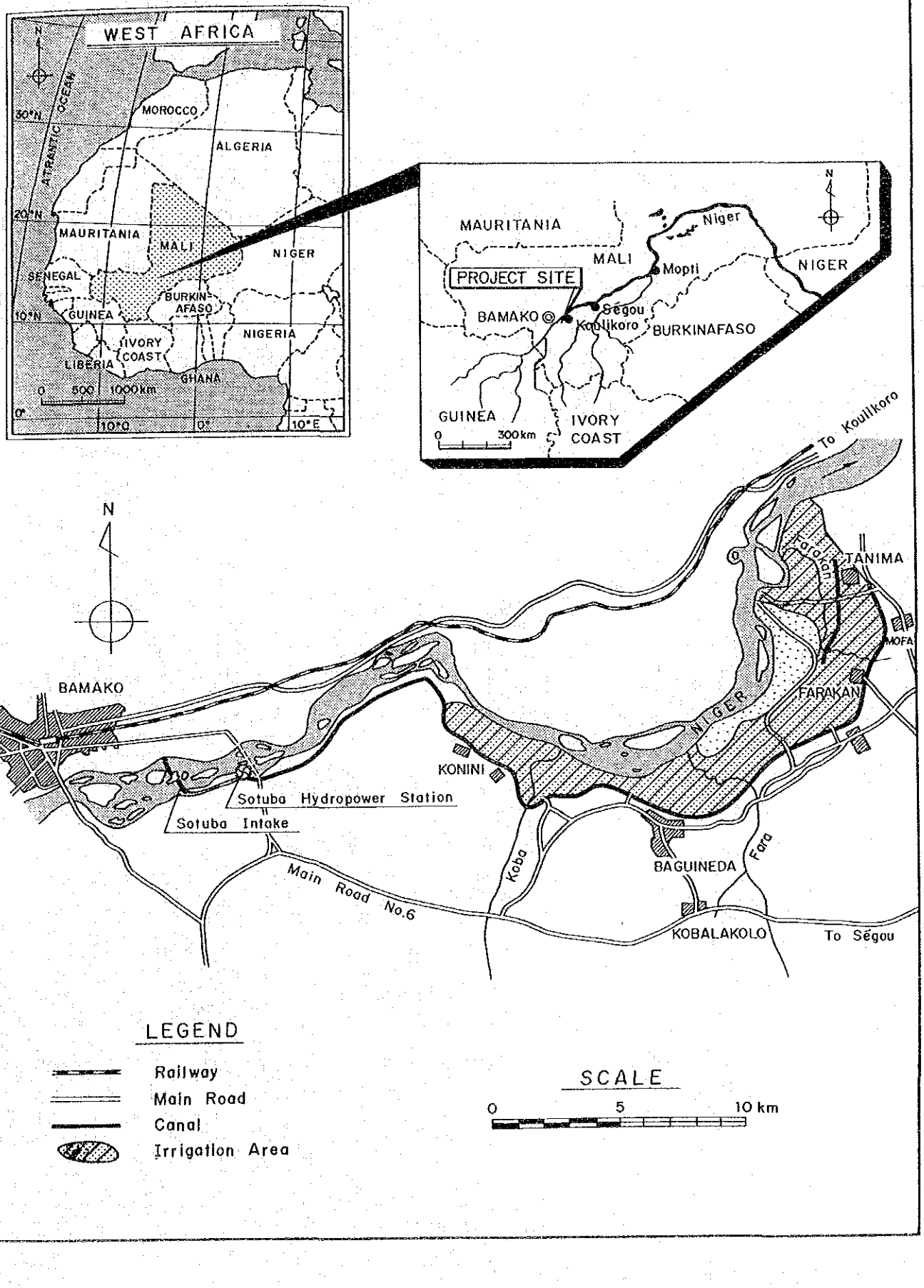

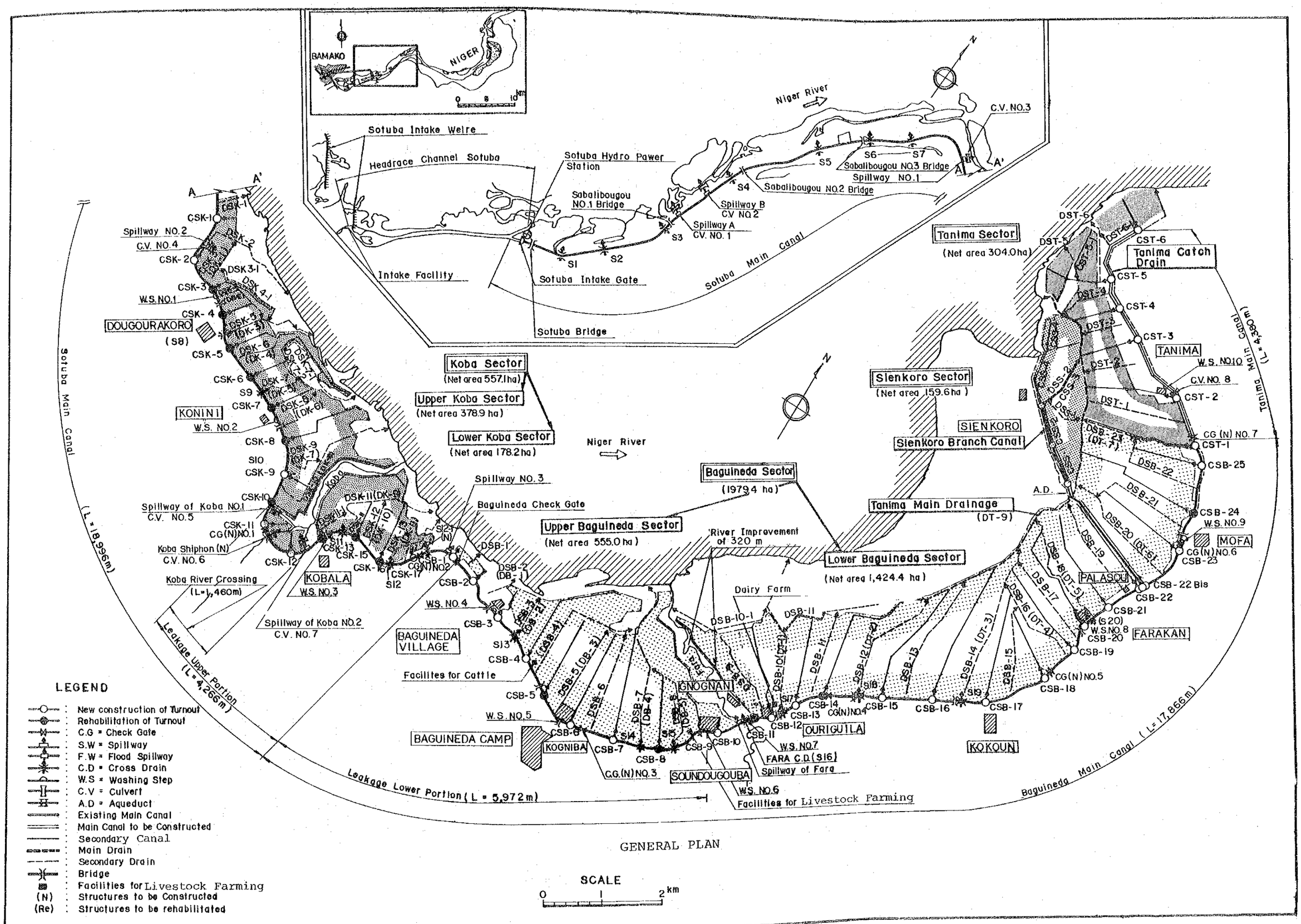

GENERAL PLAN

UPDATING FEASIBILITY STUDY

ON

THE BAGUINEDA AGRICULTURAL DEVELOPMENT PROJECT

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LIST OF ABBREVIATIONS

AFB	Abattoir Frigorifique de Bamako (Bamako Slaughter-House and Cold Storage)
ADRAO	Association pour le Développement de la Riziculture en Afrique de l'Ouest (West Africa Rice Development Association)
BCAO	Banque Centrale pour l'Afrique de l'Ouest (Central Bank of West Africa)
BNDA	Banque Nationale de Développement Agricole (anciennement la "SCAER") (National Agricultural Development Bank)
CEAO	Communauté Economique de l'Afrique de l'Ouest (West Africa Economic Community)
CEDEAO	Communauté Economique des Etates de l'Afrique de l'Ouest (Economic Community of West African State)
CILSS	Comité Inter-Etates de Lutte contre la Sécheresse au Sahel (Permanent Inter State Committee on Drought Control in the Sahel)
CMCE	Centre Malien du Commerce Extérieur (Malian External Trade Centre)
CMDT	Compagnie Malienne pour le Développement des Textiles (Malian Textiles Development Corporation)
CMPB	Coopérative des Maraîcheurs et Planteurs de Bamako (Cooperative of Bamako Vegetable Growers and Farmers)
CMTR	Compagnie Malienne de Transports Routiers (Malian Road Transports Company)
CNRF	Centre National de Recherches Fruitières (National Fruits Research Center)
ONRZ	Centre National de Recherches Zootechniques (Sotuba) (National Center for Researches on Animal Breeding (Sotuba))
DNAE	Direction Nationale des Affaires Economiques (National Directorate of Economic Affairs)
ECIBEV	Establissement de Crédit et d'Investissement Bétail-Viande (Cattle-Meat Credit and Investment Agency)
EDM	Energie du Mali (Mali Power Company)
FAC	Fonds d'Aide et de Coopération (Fund for Assistance and Co-operation)
FRUITEMA	Société Malienne pour la Commercialisation des Fruites et Légumes (Company for Marketing of Fruits and Vegetables of Mali)
IRAT	Institut de Recherches Agronomiques Tropicales et de Cultures Vivrières (Tropical Agriculture and Foodcrops Research Institute)
LCV	Laboratoire Central Vétérinaire (Central Veterinary Laboratory)
ODIB	Opération de Développement Intégré de Baguineda (Opération Baguineda) (Baguineda Integrated Development Operation)

OMBEVI	Office Malien du Bétail et de la Viande (Malian Livestock and Meat Office)
ON	Office du Niger (Niger Office)
OPAM	Office des Produits Agricoles du Mali (Farm Products Office of Mali)
OPSS	Opération Production Semences Sélectionnées (Selected Seeds Production Operation)
OSRP	Office de Stabilisation et de Regulation (Office of Price Stabilisation and Regulation)
OTER	Opération des Travaux et Equipement Rural (Rural Public Works and Equipment Operation)
RCFM	Régie des Chemins de Fer du Mali (Railways Administration of Mali)
SAT	Société Africaine de Transports Routiers Marchandises (African Company for Road Transports of Goods)
SCAER	Société de Crédit Agricole et d'Equipement Rural (Agricultural Credits and Rural Equipment Company)
SEPAMA	Société d'Exploitation des Produits d'Arachides du Mali (Groundnut Products Development Corporation of Mali)
SEPOM	Société des Produits Oleagineux du Mali (Oil Products Development Corporation of Mali)
SMECMA	Société Malienne d'Etude et de Construction de Matériel Agricole (Company for the Study and Material Construction of Mali)
SOCAM	Société des Conserves Alimentaires du Mali (Canned Food Production Company of Mali)
SOMIEX	Société Malienne d'Import et d'Export (Import-Export Corporation of Mali)
SRCVO	Station de Recherches sur les Cultures Vivrières et Oleagineuses (Sotuba) (Foodcrops and Oil Seeds Research Station (Sotuba))
STI	Société des Transports Internationaux du Mali (Company of International Transports of Mali)
UDPM	Union Démocratique du Peuple Malien (Democratic Union of the People of Mali)
ULB	Union Laitière de Bamako (Bamako Dairy Union)
UNTM	Union Nationale des Travailleurs du Mali (National Union of Malian Workers)

CONCLUSION AND RECOMMENDATION

Introduction

1. This report is prepared in accordance with the Agreement on the Updating Feasibility Study on Baguineda Agricultural Development Project, signed between the Government of the Republic of Mali and the Government of Japan in 1985. The Agreement is aimed at updating the previous feasibility study on the rehabilitation of the Baguineda Agricultural Development Project made by the Japan International Cooperation Agency (JICA) in 1981.

2. Pursuant to the Agreement, JICA dipatched a survey team to Mali from 4 October to 16 November 1985 to collect additional data and information and to execute supplemental field survey and investigation. Based on the results of these field works, the review and updating of the previous feasibility study was made in Japan from mid-November 1985 to the end of January 1986. The report presents the results of all these review and updating works.

Background

3. The Republic of Mali is a landlocked country in West Africa with an area of 1.24 million km^2, about 60% of which belongs to the Sahara Desert. The total population was 7.28 million in 1982 and is increasing at a rate of 2.5 to 2.6% per year. The majority of the population lives in the Southern region along the Niger river and engaged in agriculture.

4. The primary sector which is the mainstay of Malian economy accounted for 47.4% of total GDP in 1984. The tertiary sector occupied 34.1%, while the secondary sector remained only at 18.5%. The per capita income was 46,236 F CFA (US$ 108.5) in 1984 and the World Bank puts Mali among the LLDC with a per capita income of less than US$ 110. The international trade balance is under chronical deficits. Imports

accounted for 148.4 billion F CFA (US$ 348 million) in 1984 against exports of 80.6 billion F CFA (US$ 189 million). More than 80% of the exports is occupied by agricultural products consisting mainly of such products as cotton, groundnuts, livestock, etc.

5. Crops are produced in about 2 million hectares of farmland distributed mainly in the southern and central regions mostly under rainfed condition. Main crops are millet and sorghum, the people's major diet, and such export crops as cotton and groundnuts. Rice is produced mostly under irrigated condition along the Niger river. Rice production area covers about 200,000ha and the annual production ranges from 140,000 to 240,000 tons.

6. Mali was once called the granary of West Africa. However, she has lost her self-sufficiency in food as the result of the recurrent Sahel draughts in 1973-74, 1978-79 and 1982-83. Grain shortage amounted to 300,000-480,000 tons in 1984. Under such situation, the Government of Mali set up the 1981-85 Five Year Development Plan with emphasis on; (i) recovery of food self-sufficiency; (ii) adequate supply of raw materials to agro-based industries; (iii) development of export-oriented crops; and (iv) improvement of social environment at rural level.

The Project Area

7. The project area is located on the right bank of the Niger river, 30 to 40 km downstream of Bamako, with a gross area of 4,500 ha of which 3,000 ha are irrigable. The area develops in the alluvial plain of the river with a flat topography and a land surface elevation between El.302 m and 315 m. The area is divided into four sub-areas i.e. Koba (557 ha), Baguineda (1,979 ha), Tanima (304 ha) and Sienkoro (160 ha) by the tributaries of the Niger river. The soils in the area consist mainly of Greysols, suitable for irrigation farming.

8. The area is under the influence of the Sudanese climate characterized by alternation of dry and rainy seasons. The total annual rainfall is about 1,000 mm of which about 90% concentrates in the rainy

season from June to September. The annual mean temperature is 28°C ranging from more than 30°C in April to 25°C in January. The annual total evaporation (Class A Pan) reaches about 2,700 mm with a daily average of 7.2 mm. The relative humidity is 54% and sunshine hours are about 8 hours per day on an average.

9. The Niger river, which is the water source for the Project, has a length of about 750 km and a catchment area of 117,000 km^2 at Sotuba where the water intake for the Project is located. With the Selingue dam in operation since 1980, the river discharge at Sotuba can be kept at about 100 m^3/sec under the probable lowest discharge condition of a 1/10 probability, which meets the irrigation requirement of the Project and that of the hydropower station at Sotuba. The hydropower station has an extension plan needing more water requirement which will, however, be met by increased release from the Selingue dam. Flood discharge of the river exceeds some 8,000 m^3/sec with a probability of 1/100. The corresponding flood water level will, however, be kept lower than the lowest land surface of the project area.

10. The project area is provided with irrigation and drainage facilities that have been constructed more than 50 years ago. These facilities consist of: (i) headworks at the Niger river located about 5 km to the east of Bamako; (ii) three main irrigation canals i.e. Sotuba, Baguineda and Tanima of about 43 km in total including secondary canals related to them; (iii) main and secondary drains; and (iv) tertiary canals and the so-called on-farm facilities. Due mainly to heavy deterioration, these facilities cannot function as intended and the present irrigation area is limited only to some 300 ha.

11. Agriculture in the area is sustained by assistance and guidance of the Baguineda Operation which was established in 1972 as one of the 16 ODRs (Rural Development Operation) under the Ministry of Agriculture. The Baguineda Operation, which has four divisions and some 120 staffmembers, is providing the farmers with such services as irrigation, farm inputs supply, rental of farm machines, agricultural extension, commercialization of farm products, etc. It is operated mainly with

subsidies from the Government as well as water charge and rental charge of machine levied on farmers. The Operation covers 877 farm households of 7,064 inhabitants living in 17 villages.

12. The present land use consists of 280 ha of irrigated paddy fields, 460 ha of rainfed upland crops fields, 40 ha of orchard, bushes and shrubs covering 350 ha, etc. Although paddy cultivation has increased from only 90 ha in 1980 to 280 ha at present, the greater part of the area is still kept fallow owing mainly to lack of water. A typical farmer holds 3 ha of farmland, 0.9 ha within the project area and 2.1 ha outside. In recent years, the area produces about 160 tons of sorghum and millet, 240 tons of maize, 390 tons of paddy, 10 tons of groundnuts, 1,770 tons of tomato, 1,720 tons of onion, 340 tons of mangoes, etc. In addition, the area raises livestocks comprising 5,033 cattle heads, 1,300 sheep and goats, 300 donkeys, 3,000 chickens and other poulty.

13. Agricultural products of the area are marketed through different routes according to crops. Until 1981, OPAM (Mali Agricultural Product Office) had been the sole state agency to deal with cereals. However, such monopolistic power was abolished recently and most of the cereals are sold directly to private traders. Export-oriented vegetables are dealt with by FRUITEMA (Mali Fruits and Vegetable Commercialization Company), while non-export vegetables are sold at local markets. SOCAM (Mali Food Cannery Company), which is located immediately adjacent to the project area, produces tomato catsup, tamarind sirup, mango juice, etc. For such production, SOCAM purchases 1,800 tons of tomato and 1,000 tons of mango from the farmers in and around the area. Cow milk is sold to ULB (Bamako Dairy Union) which has a processing factory at Sotuba with a capacity of 30,000 lit./day.

14. The gross revenue of a typical farm in the project area is estimated at 705,000 F CFA per annum (US$ 1,655), of which 695,000 F CFA (US$ 1,631) are derived from agricultural activities. On the other hand, the gross expenditure is estimated at 680,000 F CFA per annum (US$ 1,596), which cover the crop production cost and living expenses. This

means that the farmers remain at subsistence level with only 25,000 F CFA (US$ 59) of net income per annum.

The Project

15. In view of the present situation of the area and in line with the national policy for agricultural development, the basic concept for the Project is set at : (i) to rehabilitate and improve the present irrigation facilities so as to realize well-sustained year-round irrigation, and based on it; (ii) to establish an agricultural development centre in the vicinity of Bamako aiming at supply of food to the capital city, supply of raw materials to the existing agro-based industries, exports of vegetables, etc. More specifically, the Project is aimed at increasing cereal production, mainly, rice, supplying tomatoes to SOCAM, increase of export crops such as French beans by intensive farming to be sustained by year-round irrigation.

16. The proposed agricultural development consists broadly of the cereals and vegetables cultivation on a small holder system and the fodder crop cultivation on a force account system of the Baguineda Operation. The total irrigation area of 3,000 ha will be allocated to the former by 2,600 ha and to the latter by 400 ha. The proposed farm size of the small holder system is 1.2 ha per farm household and hence, the total number of the farm households amounts to 2,166. Since the number of the existing farm households is 877, the balance of 1,289 households will have to be immigrated from other areas.

17. The proposed land use is tabulated as below.

(Unit: ha)

Proposed Crops	Rainy Season	Dry Season	Total Area
Paddy	2,400	-	2,400
Maize	-	1,600	1,600
Sorghum & Millet	-	200	200
French beans	-	150	150
Tomato	-	350	350
Onion	-	100	100
Others	200	200	400
Fodder crop	400	400	800
Total	3,000	3,000	6,000

Paddy is proposed as the main crop in the rainy season, whereas a diversity of vegetables will be planted broadly in the dry season for local market and for European market.

18. On the basis of experimental data and information obtained at SRCVO, the Baguineda Operation, SOCAM, etc., the anticipated crop yields are estimated and the expected production are calculated as follows:

Crop	With Project		Without Project		Increase in Production
	Yield (t/ha)	Production (t)	Yield (t/ha)	Production (t)	(t)
Paddy	4.0	9,600	1.4	390	9,210
Maize	3.0	4,800	1.1	240	4,560
Sorghum & Millet	2.0	400	0.7	160	240
French beans	2.0	300	-	-	300
Tomato	25.0	8,750	11.8	1,770	8,980
Onion	25.0	2,500	21.5	1,720	780
Potato	8.0	800	-	-	800
Watermelon	20.0	2,000	-	-	2,000
Okra	4.0	400	-	-	400
Groundnuts	1.5	150	0.6	10	150

19. The livestock development plan aims at producing 9,000 lit./day of milk to be supplied to ULB under the direct management of the Baguineda Operation. The plan consists of breed selection, planting of fodder crops and provisions of facilities such as cowshed, milk refrigerator, cattle dip, exercise area, etc. The maximum number of cows will be 2,140 heads, consisting of 1,460 heads of milk cows, 460 heads of calves and 220 heads of first calving.

20. The facilities required for the envisaged agricultural development would include rice mills, conditioning and sorting facilities for French beans and a tomato processing factory. The proposed rice mills would be of one-pass system consisting of only one machine for all the processing of husking, separation of husk and brown rice, whitening and bran removal. It is estimated that total 13 rice mills with a capacity of 600 kg per hour would be required for the

Project. Processing of tomato and sorting of French beans would be carried out in the existing facilities of SOCAM and FRUITEMA. These facilities have enough capacity to process the anticipated quantities of the products.

21. The rehabilitation and improvement plan of the irrigation and drainage plan is formulated based on the following basic engineering consideration.

(i) In view of the fact that severe leakage in the main canal is the biggest problem in Baguineda Operation, the first priority in the works should be put on prevention of leakage.

(ii) Waste of water is also caused by lack of the main canal right bank embankment at several places. Consideration should also be paid to provision of such embankment.

(iii) From the cost-saving's viewpoint, the existing structures should be utilized so far as practicable. With regard to some structures, however, replacement should be considered to ensure the introduction of rational water management and improving the present poor irrigation efficiency.

(iv) The tertiary canals and on-farm facilities are poorly provided at present. Since the establishment of a consistent canal system from the main canal to the on-farm level canals is a pre-requisite for realization of successful irrigation, these minor canals and facilities should also be provided.

22. The major rehabilitation and improvement works will consist of the followings.

I. Main irrigation canal

(1) Canal concrete lining for about 10 km long, 4 km in the most downstream part of the Sotuba canal and 6 km in the most upstream

part of the Baguineda canal, to prevent severe water leakage.

(2) Prevention of release of canal water to the Koba river by the construction of a siphon of about 90 m long at the Koba river crossing portion to pass irrigation water under the riverbed.

(3) Enlargement of canal sections and adjustment of bottom elevations in the downstream part of the Baguineda canal for about 12 km.

(4) Replacement of the present Tanima canal with a new canal connected directly to the Baguineda canal with a length of 4.4 km.

(5) Switching the water source for the Sienkoro area from the present Tanima main drain to the Baguineda canal by extending one secondary canal of the Baguineda area.

(6) Rehabilitation of the related structures to all the main canals.

(7) Rehabilitation of the main road along the whole main irrigation canals.

II. Secondary irrigation canal

(1) Increase of secondary irrigation canals from 28 nos., 34.6 km in total to 56 nos., 78 km in total including rehabilitation of the existing ones.

(2) Provision of OM cum farm roads for all the secondary irrigation canals together with extension of the width to 3 m.

III. Main and secondary drainage canals

(1) Rehabilitation of the existing Tanima main drain of 7.2 km including mainly enlargement of the cross-section and adjustment of the bottom elevation.

(2) Construction of the Tanima catch drain along the new Tanima irrigation canal to intercept the runoff from the outside of the project area.

(3) Increase of secondary drainage canals from 30 nos., 48.5 km in total to 53 nos., 79 km in total including rehabilitation of the existing ones.

IV. Tertiary irrigation and drainage canals

(1) Rehabilitation and construction of tertiary irrigation canals of 514 nos., 258 km long in total.

(2) Provision of tertiary drainage canals spaced alternately with the irrigation canals.

V. Farm plot layout and land reclamation

(1) Standardization of the tertiary unit to about 6 ha (500 x 120 m), consisting of 5 plots of farmland each having a size of 1.2 ha (100 x 120 m).

(2) Land reclamation, consisting of clearing and rough levelling works, along with the standardization of the farm plot layout.

23. Upon completion of the rehabilitation and improvement works, it is expected that the Project will generate the following annual net benefis. The total annual benefit amounts to F CFA 2,717 million or US$ 6.38 million.

(Unit : F CFA 10^6)

Benefit	Crops	Livestock	Total
Gross Benefit	3,346.0	683.3	4,029.3
Production cost	1,026.4	285.4	1,311.8
Net benefit	2,319.6	397.9	2,717.5

Implementation Plan

24. The implementation plan is prepared based on the following basic concept.

- Top priority should be given to rehabilitation of the main irrigation canal especially to prevention works of severe leakage portion, of about 10 km.

- Among the five areas i.e. Koba 557 ha, Upper Baguineda 555 ha Lower Baguineda 1,424 ha, Tanima 304 ha and Sienkoro 160 ha, priority in development should be given to Koba and Upper Baguineda areas of 1,112 ha. The development of other areas are put in second or third priorities because of their locations, less socio-economic and agricultural activities and much higher development cost.

It is proposed that the works should be divided into the following three stages and executed in 55 months or in four and a half years.

25. The works included in each of the stages consist of the

followings.

Stage-1

(i) Construction of a siphon across the Koba river (L = 91 m)

(ii) Canal lining works for the severe leakage portion (L = 7.5 km)

(iii) Right bank embankment at the Koba river crossing portion (L = 1.7 km)

(iv) Construction of a demonstration farm of 86 ha

(v) Rehabilitation of major structures along the heavy leakage portion and the upstream reach of the Sotuba canal

(vi) Rehabilitation of the connection road from the highway RN-6 to the Baguineda Camp (L = 4.3 km)

Stage-2

(i) Rehabilitation of the main canal from the head of the Sotuba canal to the end of the Lower Baguineda canal, excluding the heavy leakage portion constructed in the first stage (L = 29.3 km)

(ii) Construction and rehabilitation of secondary irrigation canals for Koba and Upper Baguineda (L = 22.7 km)

(iii) Construction and rehabilitation of secondary drainage canals for the above areas (L = 31.9 km)

(iv) On-farm development including tertiary canals for the above areas, excluding the partially developed area in the first stage (1,026 ha).

Stage-3

(i) Construction of the new Tanima main canal (L = 4.4 km)

(ii) Construction and rehabilitation of secondary irrigation canals for Lower Baguineda, Tanima and Sienkoro (L = 42.2 km)

(iii) Construction and rehabilitation of main and catch drains (L = 14 km)

(iv) Construction and rehabilitation of secondary drainage canals for the above areas (L = 44.6 km)

(v) On-farm development including tertiary canals for the above areas (1,888 ha)

Organization and Management

26. As a principle the works are to be contracted to competent contractors selected through international competitive biddings. Construction supervision will be done by the Baguineda Operation with technical assistance from foreign consultants. In view of the present activities of the Operation, it is proposed to establish a Project Coordination Committee among the Directorate of Rural Engineering, Directorate of Agriculture and Rural Economy Institute. Upon completion of the construction works, the Project Coordination Committee is dissolved and the project operation will be entrusted to the Baguineda Operation under the auspices of the Directorate of Agriculture.

Project Cost

27. The project cost is estimated based on the condition that: (i) contractors are exempted from taxs and duties; (ii) land acquisition is made free of charge; (iii) price level is of October 1985 with the exchange rate of US$ 1.0 = F CFA 426; (iV) physical contingency is 10% of the direct cost; and (v) annual escalation rate is 3% for foreign currency portion and 10% for local currency portion. The total project

cost is US$ 37.0 million equivalent consisting of the civil works cost of US$ 32.7 million and the initial farm investment of US$ 4.2 million.

Item	Foreign Currency	Local Currency	Total
	US$ 103	106 F CFA	US$ 103
(i) Civil works	14,980	7,561	32,730
(ii) Initial farm investment	3,648	251	4,237
Total	18,628	7,812	36,967

The Total cost for the civil works of US$ 32.7 million includes the foreign currency portion of US$ 15.0 million and the local currency portion of F CFA 7,561 million. The breakdown of the estimate is shown as below.

Stage	Foreign Currency	Local Currency	Total
	US$ 103	106 F CFA	US$ 103
I	2,139	1,272	5,126
II	3,898	1,547	7,530
III	4,883	1,591	8,618
Physical Contingency	1,092	441	2,127
Engineering Service	1,441	582	2,808
Price Contingency	1,527	2,128	6,520
Total	14,980	7,561	32,830

Project Evaluation

28. The economic feasibility of the Project is evaluated in terms of the Internal Rate of Return (IRR) by applying the sensibility analysis with regard to such items as cost increase and production decrease. The economic cost is obtained by deducting the provision for price escalation from the financial cost, while the economic benefit is estimated on the condition that: (i) the build-up period is 5 years, (ii) for products available in international market, the prices forecast by the World Bank for 1995 is referred to, and (iii) for agricultural inputs, custom duty and import tax of 13% are exempted. The IRR is estimated at 13.5%, which shows a rather high economic viability of the project.

29. The financial evaluation is made from the viewpoints of farmers and the Operation, taking into account the farmers' capacity to pay for the OM charges in the former and the repayment capacity of the investment in the latter.

30. A farm budget analysis shows that the typical farmer, holding a land of 1.2 ha, can get an annual gross income of US$ 3,560, equivalent to about 2.2 times of that of the without-Project condition, whereas the annual outgo is US$ 2,900 consisting of the farm expenses of US$ 670 and the living expenses of US$ 2,230. Accordingly, the farmer can reserve US$ 660 as the capacity to pay. Since farmers are kept at the subsistence level at present, these estimates demonstrate the attractiveness of the Project seen from the farmers' viewpoint.

31. The repayment capacity of investment fund from the standpoint of the Operation is studied by means of cash flow analysis which would be discounted on the basis of anticipated income and fund requirement of the Project. It is assumed that the investment fund required for project realization be provided under the conditions: (i) the foreign currency component will be financed by a bilateral or international agency in the form of a loan with the service charge of 0.75% per annum and the repayment period of 50 years including a grace period of 10 years; (ii) the local currency component will be allocated from the national budget; and (iii) the net revenue would comprise water charge

and net income from livestock production. The result of the analysis reveals that the large portion of the loan amount could be repaid by the Operation in and after 1991. Furthermore, since the annual income of the livestock products reaches US$ 934 thousand at the full development stage, the Operation could make an annual net reserve of US$ 240 thousand to US$ 578 thousand, which may be enough to cover the local currrency component allocated from the national budget.

32. In addition to the direct benefit mentioned above, the implementation of the Project would bring about favourable but intangible socio-economic impacts such as foreign currency saving and earning, development of agro-based industries, creation of job-opportunities, stability of the rural economy and improvement of general welfare, formation of an experienced and skillful man-power which will be useful for development of Mali in future.

Recommendation

33. The fore-going paragraphs show a clear picture of the Project seen from technical, economic and financial viewpoints. The Project will not only contribute to the improvement of the agricultural and socio-economic situation of the area, but also serve as a model of overall and intensive agricultural development in Mali thanks to its favourable location near the capital city. It is recommended that the Project be implemented immediately with due attentions to the followings:

(1) Prevention of water leakage in canal and structures is a problem of utmost importance and of urgent need. In line with the implementation schedule proposed in this report, it should be implemented as soon as possible.

(2) Establishment of a consistent and systematic irrigation system from main canals to on-farm level is a pre-requisite for successful performance of an irrigation project. In this sense, it is recommended that a part of the area is selected and a

consistent canal system is provided to the on-farm level, at the same time the with the execution of the above-mentioned leakage prevention works. The area is expected to act as a model for succeeding construction of the secondary and on-farm canals as well as for demonstration of the proposed rational water management. As the area for model, a part of the Upper Baguineda area (86 ha of CSB-5) is recommended. The unit is located almost in the center of the project area and is intensively used for crop production at present. Because of its favourable location, the demonstrational effect can be largely expected. It is expected that operation of the demonstration farm can be executed by the hand of Baguinela Operation. For enhancement of their ability, overseas training will be desirable.

(3) For execution of the construction and rehabilitation works, it is imperative to minimize the damage to the present agricultural activities: suspension time of water supply for irrigation should be shortened so far as possible. In this sense, the works should be implemented as proposed, making full use of the dry season from October to May. Preparatory works such as financial arrangement, mobilization of the staff of the Government and Operation, tender and contract awarding, etc. should be carried out timely and promptly so as to sustain the above schedule.

(4) The Project is aimed at the overall agricultural development encompassing such activities as cereals and vegetable production on a small holder system, livestock production by the Operation, supply of raw matereials to agro-based industries, etc. Inter-departmental cooperation among the Government- and quasi-Government agencies will be indispensable for the successful implementation of the Project.

(5) Although the target yields of the proposed crops are conservatively set up, most of them are higher than the present crop yields. For obtaining the anticipated high yields, the agricultural support services by the Baguineda

Operation are essential. Technical advices in farming practices and farm inputs supply to the farmers should be carried out smoothly under the responsibility of the Operation.

(6) Vegetable production is one of the main objectives of the Project. Because of its high profitability, farmers are eager to produce vegetables. However the prices of vegetables are quite unstable due to the balance of demand and supply particularly in the markets in Bamako. Therefore, it is recommended to prepare a crop planting programme for every campaign in collaboration with the Rural Economy Institute (IER). In connection with agricultural support services, the Operation should provide guidance on the planting period, planting hectarage, farm input, etc. to the farmers.

(7) In contrast to the rather sophisticated facilities of the ULB plant, Mali has yet to realize modern milk cow breeding method. In due consideration of the tropical climatic condition, the proposed livestock development plan should be executed under the technical assistance by LCV (Central Veterinary Laboratory) and CNRZ (National Center for Researches on Animal Breeding). Especially for the introduction of pure-bred milk cow and infectious disease control, the technology of LCV and CNRZ should be widely applied to the Project.

(8) The Project involves resettlement of about 1,290 farm families. The resettlement plan and schedule should be established among the Government agencies concerned so as to realize the resettlement programme along with the proposed implementation schedule of the Project.

1. INTRODUCTION

1.1 Authority

This report is prepared in accordance with the Agreement on the Updating Feasibility Study on Baguineda Agricultural Development Project, signed between the Government of the Republic of Mali and the Government of Japan on 1st July 1985.

Pursuant to this Agreement, the Japan International Cooperation Agency (JICA) despatched a survey team composed of six experts to Mali for the period of 4 October to 16 November 1985 to collect additional data and information and to execute supplemental field survey and investigation. Based on the results of these field works, the review and updating of the previous feasibility study in 1981 was made in Japan from mid-November 1985 to January 1986. This report presents the results of all these review and updating works.

1.2 Project History

The Baguineda Perimeter was established for irrigated rice production in the 1920s by French administration with a total area of 4,000 ha. During the 1930s, about 3,600 ha were used for rice cultivation while the remaining 400 ha were cultivated with other crops under the management of the Niger Office.

When Mali regained its independence in 1960, the Niger Office moved to Segou and the Baguineda Perimeter was more or less abandoned. Consequently agricultural production in the area declined due to the degradation of the hydraulic system. In 1962, the Government of Mali converted the Perimeter into a state farm and received various foreign aids to restore its facilities. But the aids were either too small or so partitioned that the entire repair works could not be realized.

Since 1972, the Government of Mali has established 16 agricultural agencies called "operations". The Baguineda Integrated Development Operation (Baguineda Operaation) was one of them and took over the management of the Baguineda state farm. Although it annually received 50 to 200 million MF from the French Government to repair the irrigation facilities, it could cover only urgent and emergency works needed for the systems.

It was in such situation that the 1973-74 drought struck the Sahel region and particularly affected Mali. Japan provided assistance to the drought affected countries and in this context, the previous feasibility study was realized for the re-development of the Baguineda Perimeter in 1981. Based on this feasibility report, the Government of Mali made every effort to rehabilitate the Baguineda Perimeter. But drought struck again the Sahel region in 1982-83. As in the past, international agencies and donor countries cooperated to provide foods to the Sahel region.

Japan realized that Mali possesses large potentials for agricultural development and resolved to provide further assistance to the Baguineda Project. As a first step toward its rehabilitation, the present updating feasibility study was undertaken by JICA.

1.3 Objectives and Scope of the Study

The objectives of the study consist of the followings:

(i) Review and update the technical and economic feasibility of the Project on the basis of current situation in Mali;

(ii) Foqezxate stepwise development plan; and

(iii) Undertake on-the-job training of the counterpart personnel in the course of the study.

The scope of the works was divided broadly into two categories i.e., Work-I: Additional data collection, supplemental field survey and investigation and review of the basic concept of the Project, and Work-II: Review of the previous development plan of the Project and preparation of the updating feasibility study report. The former work was executed in Mali, whereas the latter work, in Japan.

1.4 Activities of the Study Team

The first group of the study team arrived at Bamako on 6 October 1985 and the second group on 13 October. An Inception Report meeting was held on 9 October with officials of the Ministry of Agriculture, Government of Mali, and a JICA representative from Tokyo, and the report was accepted by the Government of Mali with minor modifications. The field works were started immediately and continued to the beginning of November 1985 with the participation and cooperation of counterpart personnel provided by the Ministry of Agriculture. In succession, an Interim Report was prepared and submitted to the Government of Mali on 9 November, and an explanation and discussion meeting was held on 11 November with officials of the Ministry of Agriculture. The report was accepted by the Government of Mali and the stagewise development plan, included in the report, was agreed subject to modification and more brushing up in the final report. The team left Mali for Japan on 12 November and, visited the Japanese Embassy in Senegal on the way, and arrived in Japan on 16 November.

The works in Japan consisted of compilation and analysis of the collected data and information, review and updating of agricultural development plan, rehabilitation plan of irrigation and drainage facilities, layout and feasibility study level design of the rehabilitation works, stagewise development plan, implementation plan and schedule, benefit and cost estimate, economic and financial analysis, etc. All these works were carried out from mid-November 1985 to January 1986 and the draft feasibility report was prepared at the end of January.

Explanation of the draft report to the Government of Mali was made from January 31, 1986 to February 10 including that to the Embassys of Japan to Senegal. The report was accepted by the government with minor modifications and it was agreed that final printing of the report be started in succession. Basic thereupon, this final report has been prpared in the end of March 1986.

2. GENERAL BACKGROUND

2.1 Land and Climate

The Republic of Mali is a landlocked country covering 1,240,000 km^2 in western Africa. It lies between 10°50'N and 25°00'N in latitudes, and between 4°50'E and 12°50'E in longitude (See Fig. 2.1). Landscape of Mali is relatively flat and 90% of its territory lies between El. 300 and 400 m.

The climate varies greatly depending upon latitudes. The northern portion of Tombouctou is broadly covered by vast desert, where the mean annual rainfall is less than 250 mm. The central portion between Mopti and Sikkaso is rather humid with 600 m to 1,200 mm of rainfall. In this zone, three seasons are distinguished; the cool and dry season from November to February, the hot and dry one from March to May and the cool and rainy one from June to October. The project area falls in this zone. On the south of Sikkaso, the land is fed by relatively high rainfall of more than 1,200 mm a year.

The Niger river is an important water resource of Mali. It rises in Fouta Djalon mountains of Guinea and flows passing through central Mali toward the Republic of Niger. Its watershed at Koulikoro is 117,000 km^2. Between Segou and Tombouctou, the river forms a few million hectares of Inner Delta. Being richly endowed with fertile soils, this lowlying land has been broadly used for wetland paddy cultivation.

2.2 Population

The total population of Mali was recorded at 7.28 million in 1982. With 2.5 to 2.6% of annual growth rate, it is estimated to attain 8 million in 1985. The population of Mali is characterized by its distribution pattern. The population and its density range widely among the seven Regions as shown in the following table.

Region	Land (1,000 km^2)	Population (1,000)	Population Density (per km^2)
Kayes	120	993	8.3
Koulikoro	90	1,540	17.1
Sikkaso	76	1,250	16.3
Segou	56	1,232	21.9
Mopti	89	1,285	14.5
Tombouctou	487	558	1.1
Gao	322	422	1.3

The working population from 15 to 60 years old occupies about 50% of the total population. Out of this active population, 90% or 3.8 million are engaged in agriculture and other houseworks.

2.3 National Economy

The GDP of Mali in the past 4 years is presented below.

(In billions of 1982 F CFA)

Item	1981	1982	1983	1984
Primary sector	178.4	194.3	173.8	171.3
Agriculture, forestry, livestock, fishery	178.4	194.3	173.8	171.3
Secondary sector	50.5	50.2	53.7	56.5
Industry, energy	26.5	29.2	31.2	34.0
Others	24.0	21.0	22.5	22.5
Tertiary sector	101.5	108.4	113.9	118.1
Transport and telecommunications	11.5	12.6	13.6	14.0
Services and domestic services	11.6	12.7	12.9	13.1
Trade	57.3	60.5	63.6	66.1
Administration	27.3	29.0	30.4	31.6
Unforseeable activities	-6.2	-6.4	-6.6	-6.7
GDP at factor cost	330.4	352.9	341.4	345.9
Taxes	13.4	13.5	15.1	15.2
GDP at market prices	343.8	366.4	356.5	361.1

Source: Estimates of the Ministry of Planning, Project MLI/82/002, based on the National Accounts of the Republic of Mali.

As shown above, the primary sector is the mainstay of Malian economy. In 1984, it accounted for 47.4% of total GDP. The per capita income calculated at F CFA of 1982 was 46,236 F CFA in 1984. The World Bank put Mali among the LLDC with a per capita income of less than US $110 in 1983.

Industrial production is geared mainly to import substitution and agricultural processing. Textile production is the most important activity. Other agricultural processing activities involve sugar and groundnut oil production. State enterprises play an important role in the industrial sector accounting for more than 70% of Malian industrial production.

Malian exports have been greatly affected by factors outside its power. The decline in prices of traditional crops such as cotton and groundnuts in international market, price increase of imported products, worldwide inflationary trends, the strength of the US dollar have unfavourably affected Malian economy.

Although Malian exports have substantially increased since 1981, exports could cover only less than 50% of its imports. In 1984, exports and imports accounted for 80.6 billion F CFA and 148.4 billion F CFA respectively.

The imported goods are widely varied. They are i) machinery, apparatuses and transportation equipment, ii) oil products, iii) food products, iv) chemicals and v) construction materials. At present, Mali imports a large amount of construction materials, especially cement, and textiles to cover the domestic demand.

2.4 Agriculture

(1) Crop production

Crop production in Mali is dependent mostly on the wetter zones covering about 3 million ha in the central and southern portions of the country. Out of 3 million ha, 2 million ha are presently cultivated. The staple food crops in Mali are millet and sorghum, which constitute the main diet of the people. The following table shows the planted areas and productions of main crops in 1982.

Crop	Planted Area (10^3 ha)	Production (10^3 t)	Unit Yield (t/ha)
Millet	921	429	0.7
Sorghum	441	427	1.0
Paddy/1	100	153	1.5
Maize	47	89	1.9
Wheat	47	24	0.5
Groundnuts	145	94	0.6
Cotton	104	116	1.1

Remarks: /1: only for irrigated paddy in ODR

Millet and sorghum are planted mostly under rainfed condition. Since no varietal improvement has been achieved, the unit yields of both crops are quite low at less than 1.0 t/ha.

On the other hand, a large portion of the irrigated land is used for paddy cultivation. Being endowed with ample water and fertile soils, paddy cultivation is prevailing especially in Inner Delta. Out of 200,000 ha of the total irrigated land, about 40,000 ha are planted with paddy under the management of the Niger Office. Besides, 60,000 ha are also cultivated with paddy by the low-cost irrigation technique consisting of flood control practices. They are mainly under the management of various Operations for Rural Development (ODR).

Apart from irrigated paddy, some 40,000 to 60,000 ha are traditionally planted with rainfed paddy by local farmers. They are cultivated entirely under rainfed condition, and suffer from seasonal flooding and drought. For this reason, the unit yield is very low at 0.4 to 0.6 t/ha.

Groundnuts and cotton have been cultivated, as major export crops, under rainfed condition. The production of groundnuts has declined remarkably in recent years because of stagnating yields, steep increases of prices of farm inputs, and falling export prices.

(2) Livestock production

Livestock is bred for both protein intake and draft animal in the rural areas of Mali. They are cattle, sheep, goat and poultry. There were more than 10 million heads of cattle at the beginning of 1970s. Suffering from recurrent drought in 1973-74, 1978-79 and 1982/83, Mali has experienced severe losses in its livestock. The number of livestock in 1982 was recorded as follows; 2.7 million heads of cattle, 5.0 million of sheep and goats, and 0.3 million of donkeys and horses.

2.5 The 1981-1985 Five-Year Development Plan

Mali lost its self-sufficiency in food during the Sahel drought in 1973-74 and had to import 150,000 t of foodstuffs a year. Although cereals production began to regain its pre-drought level after 1975, poor distribution and exacerbation by failure of rains after 1977 caused a continuous shortfall of basic foodstuffs which was estimated at 170,000 t. In 1982-83, drought occurred again and the grain shortfall was between 300,000 and 480,000 t in 1984. This catastrophe brought an international response in drought aids and various food schemes.

Confronted with such recurrent drought, the Government of Mali set up the 1981-1985 five-year development plan placing emphasis on increasing agricultural production to reach self-sufficiency in basic food needs. The objectives of the Plan are;

(1) To restore the food balance at the end of the five-year period to meet the national demand of cereals,

(2) To satisfy the national demands for essential foodstuffs, i.e. sugar, oil, meat, fish, milk, condiment and fruits.

(3) To satisfy the needs of the population for domestic water, fire woods and traditional construction woods.

(4) To satisfy the demands of raw materials for existing national textile industries.

(5) To develop exports of industrial and food products, i.e. meat and fish, for earning foreign currency.

(6) To improve the technical, economic, sanitary, cultural and organizational structure at rural level.

3. THE PROJECT AREA

3.1 General

The project area is located on the right bank of the Niger river, 30 to 40 km downstream of Bamako, and extends on a lowlying river terrace which elongates in a east-west direction. It has a total length of about 20 km and an average width of about 2.5 km with a total area of 4,500 ha, of which 3,000 ha are irrigable.

Topographically, it lies between El. 302 and 315 m. The lands are gently sloping downward the Niger river with a gradient of about 0.2%. In addition, the area is divided into four sectors by the tributaries of the Niger, namely Koba, Fara and Farakan. The respective areas are Koba Sector (557 ha). Baguineda Sector (1,979 ha), Tanima Sector (304 ha) and Sienkoro Sector (160 ha).

Baguineda camp, which is located almost at the center of the project area, is linked with Bamako by the main road running from Bamako to Segou. Administratively, the project area is situated in Baguineda District, Kati Circle, Koulikoro Region. There exist 17 villages concerned in and around the project area.

3.2 Natural Background

3.2.1 Meteorology

Out of the 16 meteorological observation stations in the upper basin of the Niger river, three stations at Bamako, Sotuba and Baguineda can be considered to provide reliable meteorological data for assessing the meteorological conditions of the project area.

The following table summarizes the meteorological conditions of the area on a monthly basis.

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
(1) Precipitations (mm)	0.5	0.3	3.0	19.6	67.0	132.9	231.8	305.8	211.8	65.4	8.4	0.5	1,047.0
(2) Temperature (°C)													
- Max.	33.5	36.3	38.4	39.1	38.0	35.1	31.9	31.1	32.0	34.5	34.9	34.4	34.8
- Mean	25.0	27.9	30.5	32.1	31.5	29.3	27.0	26.4	26.8	27.8	26.4	25.5	28.0
- Min.	16.5	19.4	22.5	25.0	24.9	23.5	22.1	21.7	21.5	21.1	17.9	16.5	21.0
(3) Evaporation (mm)													
- Piche	7.5	8.9	9.5	8.6	6.4	4.1	2.4	1.7	1.9	3.2	5.4	6.5	5.5
- Class A Pan	7.0	8.6	9.6	9.3	8.6	7.4	6.8	6.5	6.1	5.3	5.6	6.1	7.2
(4) Relative humidity (%)	32.7	28.1	30.5	39.7	54.3	67.1	76.8	80.4	78.3	67.9	50.4	38.7	53.7
(5) Sunshine hours (hr)	8.9	9.2	8.8	8.4	8.0	8.0	7.0	6.4	7.3	8.1	8.7	8.4	8.1
(6) Wind velocity (m/sec)	2.5	2.6	2.8	2.7	2.8	2.6	2.3	2.1	1.7	1.7	2.0	2.3	2.3

(Bamako : 1955 - 1984)

3.2.2 Hydrology

The Niger river, which is one of the biggest rivers in Africa, is the water source for the Baguineda Project. It originates in Fouta Djalon Mountains in Guinea, passes through Mali, Niger and Nigeria, and debouches into the Gulf of Guinea. The river length is 748 km at Bamako, 755 km at Sotuba and 821 km at Koulikoro, respectively, and the size of the catchment area is 117,000 km^2 at Bamako and 120,000 km^2 at Koulikoro. The Sotuba rapids, where the intake of the Baguineda Project is located, lie about 7 km east of Bamako.

Fig. 3.1 shows the location of gauging stations in the upper Niger river. There is one station at Sotuba. However since the discharge data at this point is scarcely available, the river discharge is

estimated from the actual discharge data available at other stations. The estimate is made on the following formula.

$$Q = Qd + Qs - Ir$$

where, Q: Discharge at Sotuba
Qd: Discharge at Dialokoro
Qs: Discharge at Selingue
Ir: Irrigation water requirement upstream of Sotuba

The discharge at Selingue means the discharge just downstream of the Selingue dam which was constructed in 1980. Since the trial operation of the dam continued to 1984, the available discharge data at this point are quite limited. The long term discharges are, therefore, generated through a water balance calculation applying the on-going operation rule of the dam. The water balance calculation is carried out for a period from 1907 to present. The following shows a summary of average discharges at Sotuba thus estimated.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Q1	377	238	180	147	196	446	1,015	3,161	5,175	4,254	1,864	776	1,493
Q2	149	131	117	110	121	158	228	393	502	451	284	194	237
Q3	13.0	12.0	11.2	10.8	11.5	13.5	29.1	33.1	35.2	34.3	30.6	15.3	20.8

where, Q1: River discharge at Sotuba
Q2: Inflow to the head race
Q3: Inflow to the Baguineda irrigation canal

Q3 or the inflow to the Baguineda irrigation canal shows the maximum available discharge to the Baguineda irrigation canal estimated on the condition that the inlet gates to the canal are fully opened. The lowest discharges take place in April with the river discharge of 147 m^3/sec in the Niger river, 110 m^3/sec at the head race and 10.8 m^3/sec at the head of the Baguineda irrigation canal.

The probable lowest discharges are also estimated as below:

(Unit: m^3/sec)

Probability	1/2	1/5	1/10	1/20	1/50	1/100
Q1	142.5	105.8	99.6	94.6	89.1	85.6
Q2	108.5	98.6	93.1	88.6	83.6	80.4
Q3	10.77	10.36	10.18	10.06	9.94	9.88

As estimated in Chapter 4.4.3, the irrigation water requirement for the Baguineda Project is 9.25 m^3/sec in the driest month of April. It means that such requirement is ensured even under the 1/100 probable drought condition if the gates to the canal are fully opened. This is confirmed by a long term water balance calculation from 1952 to present.

The Sotuba hydropower station, which has 2 units of generator with maximum output of 5.7 MW, is operated allowing a priority to the Baguineda irrigation. According to its operation rule, the maximum water requirement in April is about 84 m^3/sec. The sum of water requirements for both hydropower and irrigation in April is, therefore, 84 m^3/sec plus 9.25 m^3/sec or about 93 m^3/sec, which is almost equivalent to Q2 or the lowest inflow to the headrace with a probability of 1/10. From this, it follows that diversion of irrigation water to the Baguineda irrigation canal is guaranteed with a probability of 1/10 even in case the water requirement for the hydropower is fully satisfied.

The Sotuba hydropower station has an extension plan, which is at the stage of feasibility study. It proposes to increase the generating capacity from 5.7 MW to 11.7 MW by installation of additional generators. The water requirement will increase proportionally. However, it is confirmed that such increase will be met by increased release from the Selingue dam.

As regards the flood discharge and water level at and around Sotuba, the estimate is obtained as follows:

Probability	1/2	1/5	1/10	1/20	1/50	1/100
Flood discharge (m3/sec)	5,098	6,126	6,807	7,460	8,305	8,938
H1 (m)	315.30	315.56	315.75	315.90	316.11	316.27
H2 (m)	299.18	299.42	299.59	299.72	299.91	300.05

where, H1: Water level of the Niger river at Sotuba

H2: Water level of the Niger river around the most downstream area of Sienkoro.

The Sienkoro area of the Baguineda Project is located in the most downstream of the Project area with the land surface elevation of about El. 302 m. Since it is higher than the above H2, it is confirmed that the area is entirely free from floods even with the probable flood of 1/100.

3.2.3 Geology and soils

The geological foundation of the project area is formed of sandstone of the Cambrian system. On the sandstone base, diluvial deposits of 5 m thick on average spreads over. In the southern part of the project area, the fan-shaped formation is recognized at the foot of the higher terraces.

The deep aquifer is fed by seepage water coming from upper terraces. Such water flows over a sandstone shelf and falls into the tributaries such as Koba river. Since the infiltration of river water is interrupted by the sandstone ridges, groundwater in the project area is not fed by the Niger river.

The major soils are classified into Gleysols which occupy about 3,600 ha or 84% of the project area. They are fine textured and generally characterized by their hydromorphic properties showing pale

coloured profile with reddish iron mottlings. It is due to the seasonal fluctuation of groundwater table at shallow depth. As a result of leaching process of bases, the soils are generally acid throughout the profiles. Only in few cases in seasonal swamps, slightly high pH values are measured, but no salt accumulation is recognized. From the standpoint of crop cultivation, low permeability and high water holding capacity are quite favourable for wetland paddy. Due to shallow groundwater, proper drainage is essential to obtain a high crop yield.

The other soils are Lithosols, Acrisols, Cambisols and Fluvisols, of which distributions are rather limited.

3.3 Land Use and Agriculture

3.3.1 Population

The total population and number of household are recorded at 7,064 and 877 respectively. As summarized below, the average family consists of 8.1 persons including 4.2 persons who are expected as available family labour force.

Sub-area	No. of Village	No. of Household	Population Total	Population Active	Persons/House. Total	Persons/House. Active
Koba	3	172	1,439	781	8.3	4.5
Upper Baguineda	4	523	3,266	1,777	6.2	3.4
Lower Baguineda	7	112	1,583	726	14.1	6.5
Tanima	2	52	614	285	11.8	5.5
Sienkoro	1	18	165	75	9.2	4.2
Total or Average	17	877	7,064	3,641	8.1	4.2

3.3.2 Present land use

Through the field levelling programme which has been carried out by the Baguineda Operation since 1979, paddy fields have extended year by year. In 1980, the total area of paddy fields was only 90 ha whereas it increased upto 280 ha in 1984. The present land use condition is summarized below:

Land Use Category	1980 ha	1980 %	1984/85 ha	1984/85 %
(1) Upland crop field	4,000	88.9	3,810	84.6
- cultivated land	1,500	-	460	-
- fallow land	2,410	-	3,350	-
(2) Paddy	90	2.0	280	6.3
(3) Orchard (mango)	40	0.9	40	0.9
Sub-total	(4,130)	91.8	(4,130)	91.8
(4) Bush and Shrub	350	7.8	350	7.8
(5) Village and miscellaneous	20	0.4	20	0.4
Total	4,500	100.0	4,500	100.0

3.3.3 Land tenure

The project area of 4,500 ha is a part of the agricultural land of 22,000 ha under the management of the Baguineda Operation. As all the project area is government owned, no farmers are allowed to own private land in the area. For their usage, the farmers usually sign contracts with the Baguineda Operation according to the following conditions of royalty.

Land Category	Paddy	Other Crops
Secured Area	400 kg paddy/ha	52,500 F CFA/ha
Non-secured Area	25,000 F CFA/ha	25,000 F CFA/ha

The secured area is a relatively flat land where irrigation water is available almost throughout the year. These lands are located mainly in Koba Area, and owing to the favourable topography, paddy can be planted. In the non-secured area, it is somewhat difficult to irrigate due to lack of water in the canals. The farmers draw up water from shallow wells dug beside the fields. These lands are located in Upper Baguineda. In the downstream area such as Lower Baguineda, Tanima and Sienkoro, the farmers usually cultivate the land without any contracts with the Operation.

Although the farm holding size per household ranges widely by location, it may be generalized that the average household cullivates 3.0 ha of farm land, out of that, 0.9 ha is located inside the project area and 2.1 ha are outside.

3.3.4 Cropping pattern and farming practices

In general, cereal crops,i.e. paddy, maize, sorghum and millet, are planted in the rainy season. The sowing starts between May and July, and the harvesting is done from September to December.

Following the harvesting time of cereals, various kinds of vegetables are sown under irrigated condition. The sowing starts in September and the harvesting is done between December and March.

As for cereals, farming practices still remain rudimentary. Only little amount of fertilizers and agro-chemicals is used for these crops. On the other hand, vegetables are rather intensively cultivated to a certain extent with irrigation and chemical inputs.

Although the Baguineda Operation is promoting the supply of farm inputs such as fertilizers, agro-chemicals and farm equipment through the agricultural support services, the application of farm inputs has decreased over the years. In 1980 a typical farmer used 88 kg of Urea and 44 kg of Ammonium Phosphate, whereas in the 1984/85 campaign only 30

kg and 21 kg are respectively used.

In addition, the Operation provides tractor hiring services for land preparation at the farmers' request. They are charged at 12,500 F CFA/ha for ploughing and 7,500 F CFA/ha for harrowing. But this activity is rather limited due to lack of machinery. The total areas applied for the services in 1984/85 are 78 ha for ploughing and 470 ha for harrowing.

3.3.5 Crop yield and production

The crop yields and production of predominant crops in the project area are summarized below:

Crop	Planted/1 Area (ha)	Unit Yield/2 (t/ha)	Production (t)
Rainy Season Crop			
Sorghum and Millet	230	0.7	160
Maize	220	1.1	240
Paddy	280	1.4	390
Groundnuts	10	0.6	10
Others	10	-	-
Dry Season Crop			
Tomato	150	11.8	1,770
Onion	80	21.5	1,720
Other Vegetables	40	-	-
Orchard			
Mango	40	8.5	340

Remarks: /1: campaign 1984/85
/2: average in last five years (1980-84)

3.3.6 Animal husbandry

The numbers of livestock raised in the project area are:

Cattle (oxen, cows)	5,033 heads
Sheep and goats	1,300 heads
Donkeys	300 heads
Poultry	3,000 units

Out of the above numbers, 1,472 heads of cattle and 790 heads of sheep and goat were slaughtered for meat production in 1984. In addition, 226,800 lit. of milk and 40,000 nos. of eggs were produced in the project area.

3.3.7 Marketing and prices

(1) Cereals

OPAM (Mali Agricultural Product Office) purchases and collects cereals directly from farmers or through farmers' cooperatives at district level. ODRs (Operation for Rural Development) are also the medium for purchasing cereals by OPAM. For smooth marketing, OPAM has branch offices at the regional and circle levels, and each of them owns cereal collecting center and transportation means.

Until 1981, all cereals had been purchased only by OPAM under the government price regulation policy. However OPAM has been deprived of this monopoly since 1982. At present, farmers are free to sell cereals to private traders or at markets.

(2) Vegetables and fruits

Vegetables and fruits are traded by individual farmers without any price control. Some vegetables, which are intended for exports as off-season products towards Europe and the Middle East, are purchased by FRUITEMA (Mali Fruits and Vegetables Commercialization Company). Main products for exports are French beans, broad beans, okra and mango.

Sweet pepper used to be exported until 1982, but it is not exported any more due to loss of markets.

SOCAM (Mali Food Cannery Company), which is located immediately adjacent to the project area, produces tomato catsup, tamarind sirup, mango juice, etc. For processing such products, SOCAM purchases 1,800 t of fresh tomato and 1,000 t of mango per month from the farmers of the Baguineda area.

(3) Dairy products

For supplying milk products to the market in Bamako, the Government established a milk processing factory, the Bamako Dairy Union (UBL). ULB located at Sotuba can produce 30,000 lit./day of milk at present. AFB (Bamako Slaughter Center) provides services for meat production with a processing capacity of 10,000 t/year.

(4) Oil crops

SEPOM (Mali Oil Products Company) has the capacity of processing 65,000 t of oil seeds per annum, e.g. 20,000 t for peanuts, 30,000 t for cotton seeds, etc. Although there is such a large processing capacity, the oil production is depressed at present due to shortage of raw materials.

3.3.8 Farm budget

The gross revenue of a typical farm in the project area is estimated at 705,000 F CFA per annum, of which 695,000 F CFA are derived from agricultural activities. On the other hand, the gross expenditure is estimated at 680,000 F CFA per annum, which cover production costs and living expenses. This means that the farmers remain at subsistence level with only 25,000 F CFA of net income per annum.

3.3.9 Agricultural support services

(1) Baguineda Operation

The agricultural development of the Baguineda Perimeter is mainly taken in charge by the Baguineda Operation, which was established in 1972 as one of the 16 ODRs under the management of the Ministry of Agriculture. As a core body the Baguineda Operation is commissioned with various supporting services to the farmers, i.e. preparation of farm inputs, tractor hiring services for land preparation, irrigation water supply, extension of agricultural technique and commercialization of farm products.

Through reorganization, the Baguineda Operation consists of the following four divisions staffed with 123 persons at present.

- Administration and finance division
- Planning, evaluation and documentation division
- Production division
- Rural engineering division

3.4 Existing Irrigation and Drainage Facilities

3.4.1 General

The Baguineda Project area is provided with irrigation and drainage facilities that have been constructed more than 50 years ago. These facilities consist of: (i) headworks at the Niger river located about 5 km to the east of Bamako, (ii) three main irrigation canals, Sotuba, Baguineda and Tanima and their related secondary canals, (iii) main and secondary drainage canals, and (iv) tertiary canals at the so-called on-farm level. Due mainly to heavy deterioration, these facilities cannot function as intended and the present irrigation area is limited to only a part of the whole area. The main characteristics and present conditions of these facilities are summarized in Table 3.1, and Fig.

3.2, respectively and their features are outlined as below.

3.4.2 Headworks

(1) Sotuba intake weir

The weir consists of a concrete-gravity fixed weir of about 1,000 m long and 3.75 m high and a movable weir of 54 m long, comprising 4 units of gates, 10 m wide and 5 m high each, at the right side of the weir. The movable weir was constructed in 1950's when the Sotuba hydropower station was constructed. The weir has been kept in rather good condition and there is no need for rehabilitation. However, there is a re-construction plan in connection to the extension plan of the Sotuba hydropower station.

(2) Intake structure and headrace

The intake structure is located at the right bank of the Niger river about 25 m upstream of the movable weir, which takes water for both the Baguineda Project and the Sotuba hydropower station. The total width of the intake is 67 m, comprising 8 bays of stoplog type inlets each 7.5 m wide and 5 m high. The maximum intake discharge is more than 230 m^3/sec.

The headrace is constructed connecting the above intake to the inlet of the Sotuba irrigation canal and the Sotuba hydropower station. It is an earth canal with a length of about 2,900 m, longitudinal slope of about 1/10,000 and maximum capacity of more than 230 m^3/sec.

Both intake structure and headrace are kept in rather good condition and there is no need of rehabilitation.

(3) Inlet to the Sotuba main irrigation canal

The inlet to the Sotuba main irrigation canal is located at the downstream end of the above-mentioned headrace, where the headrace bifurcates into the one for the hydropower station and the other, for the Sotuba main irrigation canal. Irrigation water is directed through this inlet and conveyed to the head regulator located about 120 m downstream of the bifurcation point. This regulator is a key structure

for the whole Baguineda Irrigation Project and controls the water diversion to the whole irrigation system. It is provided with two units of steel sluice gates, 2.5 m wide and 2.5 m high each, driven electrically and operated from the Sotuba hydropower station. Both inlet channel and head regulator are constructed in solid and massive rock and kept in good condition.

3.4.3 Main irrigation canal

(1) Sotuba main canal

The Sotuba main irrigation canal runs over a distance of 19 km commanding the Koba area of 557 ha and conveying irrigation water to the downstream areas of 2,443 ha. It is generally made of an earth channel with an average bottom width of about 15 m, water depth of about 3 m and longitudinal slope of about 1/20,000. The canal is not provided with embankment on the right bank in several portions i.e., at the Koba river crossing portion of about 1.4 km and at five sporadic portions of about 4.5 km in total. At these places, water from the canal spills to the right bank forming swampy and marshy lands.

Considerable deterioration has been caused in the Sotuba canal and severe water leakage occurs especially in its downstream portion of about 4 km. According to measurement of leakage executed during the previous feasibility study, the leakage rate for the whole reach is about 280 lit./sec/km, while it amounts to 610 lit./sec/km in the downstream portion of about 3 km from the Konini bridge to the Kobala bridge including the Koba river crossing portion of about 1.4 km.

Related structures to the Sotuba main canal consist of 10-turnouts, 7-spillways, 12-cross drains, 4-bridges, etc. They are being used at present. However, much rehabilitation and improvement works are needed to restore and upgrade their functions. Among others, provision of discharge measurement devices are required for the turnouts to realize equitable and rational water management.

(2) Baguineda main canal

The Baguineda main irrigation canal is a continuation to the Sotuba canal with a length of 17.8 km, bottom width of 6 to 9 m, water depth of 2.5 m and longitudinal slope of 1/27,300. As the same as the Sotuba canal, the Baguineda canal sustained severe deterioration and suffered from leakage, especially in its most upstream portion for about 6 km. According to the leakage measurement made in the previous feasibility study stage, water leakage in this portion reaches about 470 lit./sec/km on an average. It is noteworthy that in 1984, dredging works were carried out partially for the Baguineda canal for about 9.8 km (No. 26 - No. 124) and the bed siltation was taken out with an average depth of 30 cm, conforming to the design bed elevation proposed in the previous feasibility study.

Related structures to the Baguineda canal are: 1-head regulator at the beginning of the canal, 12-turnouts, 1-spillway, 8-cross drains, 10-bridges, etc., most of which are in the same condition as those of the Sotuba canal.

(3) Tanima main canal

The Tanima main canal is a small canal to irrigate the Tanima area lying in the easternmost part of the project area. It is about 6 km long with a bottom width of 5.5 m, water depth of 1.3 m, longitudinal slope of 1/5,600, etc. It takes water from the drainage canal of the Baguineda area and hence, it can seldom receive adequate irrigation water. Because of the almost chronical suspension of water conveyance, heavy siltation and bank erosion have taken place in the canal and structures.

Related structures to the Tanima canal consist of 1-head regulator at the beginning point, 3-turnouts, 2-cross drains, 1-bridge, etc. Conditions of these structures are rather worse than those of the other canals.

3.4.4 Secondary irrigation canals

There are 28 secondary irrigation canals of 34.6 km long in total comprising 10 Sotuba secondary canals of 8.9 km, 14 Baguineda secondary canals of 19.9 km and 4 Tanima secondary canals of 5.8 km. Average commanding areas of these canals are 56 ha per canal in Koba, 141 ha in Baguineda and 116 ha in Tanima including Sienkoro. The length and capacity of the canals range from a few hundred m to about 2 km and from about 0.2 to 1.0 m^3/sec, respectively. All the secondary irrigation canals are of the earth channel type and their functions have been reduced considerably due to erosion of banks, siltation, dense growth of weed, etc. The degree of deterioration is apt to advance toward the downstream of the main canal.

Related to these secondary canals, there are a great number of structures such as turnouts, checks, drops, culverts, etc., most of which have been deteriorated and almost lost their functions. As the same as the turnouts to the main canals, the turnouts to the secondary canals are not provided with discharge measuring devices, which brings about disorderly distribution of water to tertiary irrigation units.

3.4.5 Drainage canals

The drainage system for the project area consists of natural rivers such as Koba and Fara rivers, which act as the main drains, the 7.2 km long Tanima main drain, and 30 secondary drains of 48.5 km in total. These secondary drains comprise 11 drains in Koba area with a total length of 14.9 km, 13 drains in Baguineda area with a total length of 26.4 km and 6 drains in Tanima and Sienkoro areas with a total length of 7.2 km, respectively.

The Koba river is about 20 km long and has a catchment area of about 290 km^2. At present, it crosses the Sotuba main irrigation canal by means of the so-called "level-crossing" method thereby creating

a vast inundated swamp land in the right bank of the canal. The Fara river is also about 20 km long and has a catchment area of about 74 km^2. It crosses the Baguineda main irrigation canal through a cross drain, which has seriously been deteriorated causing a considerable amount of leakage of the canal water. As regards these major drains, improvement or rehabilitation works are needed for these structures to cross the irrigation canals. The Tanima main drain is a man-made canal with a bottom width of 2-4 m, water depth of 1.3-3 m and longitudinal slope of 1/750 - 1/1,000. It collects water from the Baguineda area, and after acting as the water source for the Tanima and Sienkoro areas, it flows into the Niger river. Both main and secondary drains suffer from limited capacity, erosion, and thick weed growth, etc. and various rehabilitation works are required to restore their functions.

3.4.6 On-farm facilities and farmland layout

The on-farm facilities consist of tertiary irrigation canal and supply ditch. Provision of these facilities differs for each of the areas. In the Koba area, they are comparatively well provided and tertiary canals are branched off from the secondary canal with an average interval of about 50 m and supply ditches are spaced at about 20 m intervals. One plot of the farmland covers an area of 1 to 2.5 ha. In other areas, provision of the on-farm facilities is rather poor. The tertiary irrigation canals are spaced at an approximate interval of 100-200 m and the size of one plot reaches 10 to 20 ha. Generally speaking, these on-farm facilities require further development and the farm land layout has to be readjusted.

3.4.7 OM road and farm road

The operation and maintenance road is provided on the left bank of the main irrigation canals and it serves also as the trunk transportation road within the project area. The total length is 43 km, of which the upstream part of about 37 km has an effective width of

about 4 m and the road surface is paved by laterite. However, the maintenance of the road has been poorly executed and the all-weather traffic is hardly possible owing mainly to severe deterioration of the road surface. A 2-3 m wide operation and maintenance road is provided also to each of the secondary canals and it is used also for farming purposes. It is not paved by any kind of materials and, as the result of poor maintenance, it is hardly passable especially in the rainy season.

4. PROSPECTIVE DEVELOPMENT

4.1 Constraints and Potential

4.1.1 Constraints

The project area had been developed for rice cultivation during the period from 1930 to 1959. It has a total irrigation area of 3,000 ha. Although the area is highly suitable for intensive irrigation farming, the crop planted area had decreased progressively and only 1,000 ha were being planted with cereals and vegetables in 1984. On the other hand, the remarkable recovery in planted areas was due thanks to the abundant rainfall in 1985. This fact implies that the planted area could be extended if major constraints are eliminated in future.

In view of the present agricultural conditions, the followings may be considered as main constraints of further development of agriculture in the project area.

(1) Heavy water loss due to leakage problem of the existing irrigation facilities caused mainly by deterioration of canals and structures.

(2) Inadequate management and maintenance of irrigation systems due partly to poor provision of water management and maintenance facilities and low development of tertiary and on-farm systems and partly to severe financial situation of the Baguineda Operation.

(3) Insufficient agricultural supporting services such as extension, farm inputs supply, agricultural credits, etc.

(4) Shortage of a number of farm households to cover the whole area.

4.1.2 Potentials for Development

The project area is, however, blessed with a favourable situation with good prospects for agricultural development project.

(1) The area is located in the proximity of the capital city which is a large market for farm products and has means of exporting products to foreign countries.

(2) The existing agro-industrial factories are large enough to process raw materials which will be produced in the project area.

(3) The farmers will be fully supported by the Baguineda Operation in terms of acquisition of farm inputs and trade of products.

(4) The completion of the Selingue Dam in 1980 ensures more stable irrigation water supply

(5) The prevention of leakage in irrigation canals and facilities will enable to realize double cropping under year-round irrigation.

4.2 Basic Concept for Agricultural Development

The Government of Mali gives a high priority to agricultural development aimed at the following objectives:

(1) Increase of cereals production in order to cover total demand of the country,

(2) Increase of industrial crop production by means of crop diversification under valorization,

(3) Supply of farm products to processing factories,

(4) Exports of excess products in order to contribute to financial recovery and also to promote increase in agricultural production, and

(5) Increase of dairy products in order to supply protein diet.

In line with the government policy, the Baguineda Operation has formulated the development plan of the project area which focusses on;

(1) Increase of vegetable production for both local processing and exports.

(2) Increase of milk production in order to supply milk to ULB in a quantity of 6,000 lit. per day.

(3) Introduction of smallholder farming instead of tenant system in farm management.

Judging from the potentialities and the priviledged situation of the project area, the Baguineda Agricultural Development Project will be able to attain a part of the goals envisaged by the Government and the Baguineda Operation. Under these circumstances, the basic concept is worked out as follows:

(1) Establishment of an agricultural development center aiming at supply of food to the capital city, supply of raw materials to agro-based industries, exports of vegetables, etc.

(2) Contribution to the social stability through enhancement of economic conditions of farmers and also receiving a number of immigrants from outside.

(3) Demonstration of well irrigated agriculture based on the smallholder system.

More specifically, the Project is aimed at increase of cereals production, supply of tomatoes to SOCAM for processing, increase of export crops such as French beans, increase of milk production to ULB, etc. by intensive farming sustained by the year-round irrigation.

4.3 Agricultural Development

4.3.1 Basic concept

With a view to formulating an optimum land use and a suitable cropping pattern, proposed crops are selected on the basis of natural conditions of the area, future demand of crops, crop profitability, and familiarity and intention of the farmers. As a result, paddy is proposed as a main crop in the rainy season. Since the shortage of rice in Mali is gradually increasing and would attain 169,000 t in 1995, rice cultivation in the Baguineda Perimeter is highly expected to meet a part of such shortage of rice. In addition, rice is used to be planted as a main crop in the area under the Niger Office. This means that rice is a rather familiar crop with the local farmers.

Besides, a diversity of vegetables will be broadly planted in the dry season for supply not only to local markets but also to foreign markets. In order to obtain the maximum benefit, the planted areas of vegetables are determined as large as possible.

4.3.2 Proposed land use

Taking the soil and topographic conditions into consideration, suitable land for irrigation development is estimated at 3,520 ha in total. After deduction of some areas required for construction of infrastructures, i.e. canals, roads, etc., the total net irrigable area would be 3,000 ha.

Upon completion of the new irrigation and drainage system, road network, etc., the proposed area of 3,000 ha would become irrigable and intensive land use can be achieved with the introduction of modern irrigated farming techniques. Considering the soil suitability, 2,600 ha of land will be planted with paddy and vegetables under irrigation and the remaining 400 ha covered by coarse soils along the Fara river are proposed for permanent pasture land for milk cow raising.

4.3.3 Proposed cropping pattern

For preparation of a suitable cropping pattern, the relationship between physiological characteristics of the proposed crops and climatic conditions i.e. sunshine duration and air temperature of the project area are taken into account. In addition, the most suitable period for exporting crops to overseas markets and the economical use of irrigation water are also basically considered. The proposed cropping pattern is illustrated in Fig.4.1 and summarized in following table.

(Unit: ha)

Proposed Crops	Rainy Season	Dry Season	Total Area
Paddy	2,400	-	2,400
Maize	-	1,600	1,600
Sorghum & Millet	-	200	200
French beans	-	150	150
Tomato	-	350	350
Onion	-	100	100
Others	200	200	400
Fodder crop	400	400	800
Total	3,000	3,000	6,000

4.3.4 Farm management system

At present, the farmers in the project area are allowed to cultivate the area under annual contracts signed with the Baguineda Operation. However, the smallholder farming system will be introduced after the project implementation. Taking the past experience in the farm management under the Niger Office and the situation of labour availability (4.2 persons/household) into account, the optimum farm holding size is judged to be 1.2 ha per household.

Heavy farming works such as land preparation and transportation of farm products will be carried out by the individual farmers with draft animals, instead of tractors provided by the Baguineda Operation. For this purposes, every household will be required to keep at least two heads of cattle and one calf.

For smooth operation of irrigation and drainage facilities as well as rice mill and other farm machinery, farmers cooperative associations will be organized at village or irrigation users unit levels.

4.3.5 Resettlement plan

Since the present active work force estimated to be 3,600 persons in the project area would not be sufficient to meet the labour requirement for the proposed development plan, it is essential to transmigrate people into the area.

The following table presents the required number of farmers to be resettled.

Sub-area	Irrigation Area (ha)	Area to be Allocated to the Farmers (ha)	Households (nos.)		
			Required	Existing	Resettled
Koba	557	557	464	172	292
Upper Baguineda	555/1	295	246	523	-277
Lower Baguineda	1,424/1	1,284	1,070	112	958
Tanima	160	160	133	52	81
Sienkoro	304	304	253	18	235
Total	3,000	2,600	2,166	877	1,289

Remarks: /1: including 400 ha of pasture in total

As shown above, 1,290 households are required to be resettled from outside the project area. In Upper Baguineda, the number of existing households exceeds the requirement. A total of 277 households will be resettled, therefore, to the other areas, i.e. Koba or Lower Baguineda.

4.3.6 Proposed farming practices

The most practical farming practices are set up for exploitation of the potential crop productivity with consideration to the prevailing farming practices in the project area and the technical level of local farmers.

(1) Land preparation

Land preparation for the proposed crops would be carried out by animal power. The land will firstly be ploughed and harrowed twice to ensure stabilization of the rooting of seedlings and irrigation operations. These practices would be done with plough and tooth harrow. As for rice, soil puddling and land levelling works are added by using puddling rake and level board. (2) Seeding

Two seeding methods, i.e. transplanting and direct sowing, are proposed. The first method is applied to rice, tomato, French beans, onion and okra. The second method is applied to such crops as maize, sorghum, millet, groundnuts, watermelon and potato. The unit rates of seeding of main crops are:

Rice	30 kg/ha	Tomato	0.4 kg/ha
Maize	25 kg/ha	French beans	100 kg/ha
Sorghum	8 kg/ha	Onion	5 kg/ha
Fodder crop	0.7 kg/ha		

(3) Fertilization

Application of chemical fertilizer would be essential for attaining the anticipated crop yields, since the inherent soil fertility in the project area is generally low. Prior to harrowing a basic application of fertilizer will be made to prepare a fertile soil foundation for the seedlings. The application would be made by hand using about 1/3 to 1/5 of the total requirement of fertilizer. Following top dressing would be done three to four times in order to ensure smooth growing of the plants by the split application method. The total fertilizer requirements of main crops are:

(Unit: kg/ha)

Crops	N	P_2O_5	K_2O
Rice	120	60	60
Maize	105	92	60
Sorghum	64	46	36
Tomato	185	120	210
French beans	110	110	150
Onion	105	75	135
Fodder crops	280	230	170

(4) Weeding

After seeding and transplanting, weeding would be carried out two or three times, depending on the conditions of weed growth. For efficient weeding, it is planned to use rotary weeders for rice cultivation and traditional hoes for other crops.

(5) Harvesting

Harvesting is planned to be carried out manually by farmers. However, with a view to improving the quality of marketable crops, it would be preferable to adopt modern mechanized threshing method for rice and maize. It is proposed, therefore, to introduce pedal thresher for rice and corn sheller.

4.3.7 Anticipated yield and production

On the basis of experimental data obtained at SRCVO, the Baguineda Operation, SOCAM, etc., the anticipated crop yields are estimated and the expected productions are calculated as follows:

Crop	With Project		Without Project		Increase in Production
	Yield (t/ha)	Production (t)	Yield (t/ha)	Production (t)	(t)
Paddy	4.0	9,600	1.4	390	9,210
Maize	3.0	4,800	1.1	240	4,560
Sorghum & Millet	2.0	400	0.7	160	240
French beans	2.0	300	-	-	300
Tomato	25.0	8,750	11.8	1,770	8,980
Onion	25.0	2,500	21.5	1,720	780
Potato	8.0	800	-	-	800
Watermelon	20.0	2,000	-	-	2,000
Okra	4.0	400	-	-	400
Groundnuts	1.5	150	0.6	10	150

4.3.8 Livestock development

(1) Management system

The livestock development plan aims at producing 9,000 lit./day of milk to be supplied to ULB under the direct management of the Baguineda Operation. As the rather intensive dairy farming will require quality control and prompt processing of collected milk, it would be indispensable to introduce modern ranching practices and facilities.

(2) Breed selection

Since the local cow breeds in Mali have not high milk productivity, the introduction of pure-bred species such as Jersey is planned. In view of hot and dry climate, the introduced breed should be imported from tropical countries where climatic conditions are similar to those in Mali. Printer to commencement of such import, the adaptability test and trial freeding will have to be executed to confirm their suitabilities to the local conditions in Mali. Prior to commencement of such import, the adaptability test and trial breeding will have to be extended to confirm their suitabilities to the local condition in Mali.

The introduction of milk-cows would be carried out in accordance with the progress of field consolidation of pasture land. From the 3rd to 5th year after commencement of the works, 840 heads would be imported. It is presumed that about 180 heads, i.e. 20% of the total introduced cows, would die due to nonadaptation to tropical condition.

The reproduction of milk-cows from the remaining 660 heads would continue until reaching a total of 2,140 heads consisting of (a) 1,460 heads of milk-cow, (b) 240 heads of calves (0-11 months old), (c) 220 heads of calves (12-23 months old) and (d) 220 heads of cows in 1st calving (24-35 months old). As that time, the farm would be able to produce 9,000 lit./day of milk. This production can be attained in the 8th year after the introduction of milk-cows. The discarded and discharged cows would be used for meat production. Their total number would be 22.0 head per year. As regards male calves, it is suggested that they might be used as breeders from pure species.

(3) Fodder cropping

Both fodder grasses and pulses would be produced in 400 ha of pasture land. The selected varieties are Panicum maxima, Echinochla stagnima, Pennisetum purpurem and Stylosanthes guianensis. They are cultivated under irrigation with fully mechanized operation. On the basis of the growth cycle and fodder value at each growth stage, it is planned that 6 cuts would be carried out annually.

The annual fodder production is to be 37,200 t, in fresh material, which correspond to 419,800 kg of MAD and 3,976,000 of UF. These can cover the annual energy requirement for 2,140 heads of cows, i.e. 381,000 kg of MAD and 3,545,000 of UF.

(4) Facilities

The facilities and farm machinery required for the proposed livestock development are summarized below. These facilities would be installed in three respective pasture lands as indicated in the map of General Plan.

Facilities	Number Required for 1 Station	Total Requirement
Cowshed (520 m^2)	6	18
Drinking trough	1	3
Milk refrigerator (2,800 lit.)	1	3
Antiparasitic cattle dip	1	3
Exercise area	19,200 m^2	57,600 m^2
Pasture fence	1,000 m	3,000 m
Office (80 m^2)	1	3
Tractors		
- Wheeled type (60 ps)		2
- Wheeled type (45 ps)		11

4.3.9 Marketing and price prospect

(1) Marketing

i) Cereals

The average annual production of cereals between 1978 and 1982 was 1,087,000 t which comprises 107,000 t of rice and 980,000 t of other cereals. Since 91,000 t/year of cereals were imported in the said period, it is estimated that annual consumption of cereals amounts to 1,178,000 t which correspond to 177 kg of the per capita consumption, i.e. 20.8 kg of rice and 156.2 kg of others.

Future demands are forecasted on the basis of the increase in cereals consumption per capita, i.e. 2%/year for rice and 0.2%/year for others, and the growth of the population, i.e. 2.5%/year. Since it may be assumed that future production of cereals might not increase substantially from the present production level, the shortage of cereals would substantially increase up to 831,000 to in 1995 as shown below:

(Unit: 10^3 t)

Item		Rice (Paddy)	Other Cereals	Total
Demand/1	(1)	276 (424)	1,642	1,918
Production	(2)	107 (164)	980	1,087
Shortage	(1)-(2)	169 (260)	662	831

Remarks: /1: Corresponding to the consumptions of rice and others per capita are 29.7 kg and 161.9 kg, respectively.

As well as the national demand, the regional demand in Bamako would also increase up to 163,000 t, i.e. 23,000 t of rice and 140,000 t of other cereals. In view of the favourable location of the project area, it is apparant that the surplus cereals, i.e. 5,600 t of rice and 1,900 t of others, produced in the project area would easily find markets in Bamako and partly meet the regional demand of cereals.

ii) Tomato

There exists a tomato cannery (SOCAM) in the project area, with a gross processing capacity of 8,100 t of raw tomatoes (over a period of 6 months). However, due to lack of raw material, the operation of the

SOCAM plant is being hindered. At the final stage of the project operation from 1995, a quantity of 8,750 t of tomatoes would be produced annually. Out of this, 8,100 t will be supplied to the SOCAM plant and the remainder will be self-consumed or sold to markets in Bamako.

iii) French beans

According to the forecast of exports by FRUITEMA, the quantities of French beans to be exported in 1985/86 would be 200-400 t. Demands for that in local market as well as in Europe show a tendency of increase. Therefore, it would be necessary to plan for the augmentation in their production to meet such demands.

iv) Milk and beef

At its final operation stage, the dairy farm would produce 2,800 k lit. of milk and 220 heads of beef cattle per annum. Milk would be supplied to the ULB plant. Considering the shortage of raw milk for processing by the plant, the milk supply from the Project would certainly contribute to the stable operation of ULB.

(2) Price forecast

Economic and financial prices of agro-pastoral produce and inputs were evaluated on the following basis:

- Economic prices

  (a) Calculation of actual prices of export-substitute or import products was based on international market prices of exported or imported products;
  (b) Actual prices of some products were estimated by referring to the prices forecast by the World Bank for 1995 (from current 1985 prices) for products available in international markets;
  (c) Customs duty and import tax, etc., estimated to be 13% in domestic market in Mali, were deducted from actual prices;
  (d) Actual prices of local products are factory-gate prices or local market prices of said products.

- Financial prices

Financial prices are the factory-gate prices or local market prices, as of 1985.

4.3.10 Processing facilities

The facilities required for the envisaged agricultural development would include rice mills, conditioning and sorting facilities for French beans and a tomato processing factory. It is expected that with the completion of the Project, about 9,600 t of paddy will be produced annually. As at present there is no rice mill in and around the project area, it will be necessary to install new rice mills within the project area. The proposed rice mills would be of one-pass system consisting of only one machine for all the processes of husking, separation of husk and brown rice, whitening and bran removal. It is estimated that a total 13 rice mills with a capacity of 600 kg per hour would be required for the Project. They will be separately installed in the representative villages in the project area.

Processing of tomato and sorting of French beans would be carried out with the existing facilities of SOCAM and FRUITEMA. It is considered that these facilities have enough capacity to process the anticipated quantities of products.

4.4 Irrigation and Drainage Development

4.4.1 Basic engineering consideration

From the viewpoint of engineering, it is primarily required to rehabilitate the deteriorated facilities and restore their functions to an extent that the whole irrigation area can get adequate amount of water throughout the year. In planning such rehabilitation works, due attentions should be paid to the following basic considerations.

(i) In view of the fact that severe leakage in the main canal is one of the biggest problem in Baguineda Operation, the first priority in the works should be put on prevention of leakage.

(ii) Waste of water is also caused by lack of the right bank embankment at several places. Consideration should also be paid to the provision of such embankment.

(iii) From the cost-saving's review point, the existing structures should be utilized so far as practicable. However, with regard to turnout structures, replacement should be considered to ensure the introduction of a rational water management and increase the present poor irrigation efficiency.

(iv) Tertiary canals and on-farm facilities are poorly provided at present. Since the establishment of a consistent canal system from the main canal to the on-farm level is a pre-requisite for the realization of successful irrigation, these minor canals and facilities should also be provided completely throughout the area in pace with the re-arrangement of the farm plot layout.

(v) Irrigated agriculture cannot be performed successfully unless drainage facilities are provided simultaneously. In this sense, care should be exercised to the rehabilitation and provision of the drainage canals and structures.

(vi) In addition to the above hydraulic facilities, the road system within the area should be re-established thoroughly for the sake of operation and maintenance of the canals, transportation of agricultural inputs and products, farming works and other general uses, etc.

4.4.2 Delineation of irrigation area

The original acreage of the Baguineda Operation was 4,000 ha, out of which the previous feasibility study proposes to develop 3,000 ha as net irrigation area deducting uncultivable land of 500 ha and land for

canals and roads of 500 ha. This delineation is followed in this study. From the existing irrigation system, the whole irrigation area of 3,000 ha can be divided into the following four sub-areas.

Sub-area	Irrigation Canal	Irrigation Area (ha)
I. Koba	Sotuba	557
II. Baguineda	Baguineda	1,979
- Upper		(555)
- Lower		(1,424)
III. Tanima	Tanima	304
IV. Sienkoro	Sienkoro	160
Total		3,000

4.4.3 Proposed irrigation system

The present irrigation system consists of headworks and intake, main, secondary and tertiary canals. The proposed irrigation system will follow the present system so far as practicable. The layout of the proposed canals and structures is shown in the General Map attached to the report and the outline of these facilities is summarized in Table 4.1.

(1) Headworks and intake

As explained in Chapter 3.3, these structures are still kept in good condition and they can be used in the proposed system without any rehabilitation works.

(2) Sotuba main and secondary canals

The Sotuba main canal, 19 km long, is to be rehabilitated and used as the trunk canal for the Project. The canal will be provided with 16 secondary canals consisting 9 existing and 7 new ones. Each secondary canal has an irrigation area of 35 ha in an average and it is spaced at an average interval of 800 m. The length of the canal varies from 300 to 2,000 m with an average at 760 m.

(3) Baguineda main and secondary canals

The Baguineda main canal of 17.9 km long is divided into the upper Baguineda canal of 6.9 km and lower one of 11 km, each commanding an irrigation area of 555 ha and 1,424 ha, respectively. These canals will be used also as the trunk canal of the Project with provision of considerable rehabilitation works. Secondary canals in the Baguineda area will consist of 26 canals comprising 6 existing and 20 new ones. The average irrigation area per canal is 76 ha and the average interval between canals is about 650 m. The length per canal ranges from 300 to about 3,000 m with an average of 1,500 m.

(4) Tanima main and secondary canals

The present Tanima main canal of about 6 km long will be replaced with a new canal of 4.4 km long, connected directly to the end of the Baguineda canal. The new canal will have 7 secondary canals including 2 existing and 5 new ones. The average irrigation area per canal will be 43 ha and the average spacing of canals will be about 700 m. The length varies from 530 to 1,720 m.

(5) Tertiary canals

A schematic layout of the proposed tertiary canal alignment is shown in Fig. 4.2, which is basically the same as the one proposed in the previous study. One tertiary unit, which is commanded by one tertiary irrigation canal, covers a land of 6-7.5 ha (150 x 400-500m) and the tertiary canal runs along the longer side of the unit with a length of 400-500 m. The tertiary unit is to be divided into 5-6 farm plots and each plot will get irrigation water directly from the tertiary canal through a farm inlet to be provided to each plot. All the tertiary canals will have to be constructed newly together with farm plot consolidation works.

4.4.4 Irrigation water requirement

In the previous feasibility study, irrigation water requirement was estimated based on the following conditions.

(i) Consumption use of water by each crop is calculated by multiplying the potential evapotranspiration (ETo), which is estimated by the modified Penman method, by crop coefficient (Kc), which is established by FAO.

(ii) Percolation rate in the paddy field is 12 mm/10 days in the colluvial soils and 5 mm/10 days in the alluvial soils.

(iii) Plowing and puddling water requirements are 50 mm/3 days and 130 mm, respectively.

(iv) Effective rainfall is estimated on the daily water balance method using the rainfall data in 1972, which corresponds to 1/10 probable drought year.

(v) Irrigation efficiency is assumed at 52%, consisting of application efficiency of 90%, operation efficiency of 85%, conveyance efficiency below secondary level of 85% and conveyance efficiency in main canal of 80%.

(vi) Operation hours of irrigation is 24 hours per day for paddy field and 12 hours per day for upland crops.

The present estimate of irrigation water requirement is made based basically upon the above-mentioned previous conditions. However, such factors as potential evapotranspiration and effective rainfall are re-calculated using the meteorological data collected during the present survey period. The diversion water requirement for the whole area of 3,000 ha is summarized below:

(Unit: m^3/sec)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
D.W.R	6.04	8.90	10.31	9.25	6.90	5.30	4.68	4.48	4.29	3.06	2.31	3.32

It is remarked that the D.W.R or diversion water requirement is estimated on a 10 days basis and the figures given in the above table shows the peak requirement in each month. As stated in Chapter 3.1.3, the above diversion water requirement will be insured with a probability of 1/10 even when the Sotuba hydropower station is put into full operation.

4.4.5 Design discharge for irrigation canal

The peak diversion water requirement at the head of the main canal is estimated at 10.31 m^3/sec, which is almost the same as the previous estimate of 10.34 m^3/sec. Accordingly, the following previous estimate of the design discharge is applied to the present design works.

For tertiary canal

The design discharge for tertiary canals is estimated at 2.01 lit./sec/ha on the condition that the puddling water requirement of 130 mm is supplied within a period of 10 days.

For secondary canal

The design discharge for secondary canal is estimated at 2.769 lit./sec/ha which comprises the average irrigation water requirement of crops at peak time.

For main canal

The design discharge for main canal is obtained by dividing the sum of the secondary canal requirements by the main canal efficiency of 0.8.

4.4.6 Drainage plan

Drainage water requirement within the project area is estimated at 5.0 lit./sec/ha on the condition that the maximum daily rainfall of a probability of 1/10 is 105 mm and that it is to be drained within a period of 48 hours or 2 days. Drainage water requirement from outside of the project area is assumed at 0.49 $m^3/sec/km^2$, equivalent to the specific flood discharge of the Koba river. The flood discharge from Koba and Fara rivers is estimated at 140 m^3/sec and 23 m^3/sec respectively, based on the above-mentioned probable maximum daily rainfall and the rational formula.

The proposed drainage system will comprise 1 principal drain in Tanima, 53 secondary drains, tertiary drains to be provided in each tertiary unit, and 2 catch drains along the proposed Tanima and Sienkoro irrigation canals.

The principal drain is the existing Tanima drainage canal of 7.2 km and it needs rehabilitation and enlargement. Secondary drains consist of 30 existing and 23 new canals and will be aligned alternately with secondary irrigation canals. A schematic layout of the tertiary drains is shown in Fig. 4.2. Catch drains are to be newly constructed along the Tanima and Sienkoro irrigation canals, respectively. These drains are to evacuate the overland runoff from the outside of the project area, which flows into irrigation canals at present.

4.4.7 Road network

The proposed road network consists principally of main, secondary and tertiary roads. A main road is provided to the main irrigation canals with a total length of 41.3 km and a width of 5 m. Secondary roads are to run along all the secondary irrigation canals with a total length of 62.6 km and a width of 4 m. Tertiary road are to be laid along all the tertiary canals with a width of 3 m. All these roads are proposed to be used for both operation and maintenance of the canals and farming purposes.

In addition to the above, it is proposed that the existing road from the highway RN. 6 to Baguineda camp (4.3 km), will be rehabilitated to be used as main access to the project area.

4.5 Rehabilitation and Improvement of Irrigation and Drainage Facilities

4.5.1 General

According to the previous feasibility study, the following rehabilitation and improvement works were proposed for irrigation and drainage facilities.

Main irrigation canal

(1) Canal lining by concrete for about 10 km, 4 km in the most downstream part of the Sotuba canal and 6 km in the most upstream part of the Baguineda canal, to prevent severe water leakage.

(2) Prevention of release of the canal water to the Koba river by construction of a masonry dike of about 2.2 m high and 1.4 km long at the Koba river crossing portion on the right bank of the canal.

(3) Enlargement of canal sections and adjustment of bottom elevations in the downstream part of the Baguineda canal for about 12 km.

(4) Replacement of the present Tanima canal with a new canal connected directly to the Baguineda canal with a length of 4.4 km.

(5) Switching of the water source for the Sienkoro area from the present Tanima main drain to the Baguineda canal by extending

one secondary canal of the Baguineda area.

(6) Rehabilitation of the related structures to all the main canals with maximum utilization of the existing structures.

(7) Rehabilitation of the main road along the whole main irrigation canals, the works consisting mainly of laterite pavement of 20 cm in thickness.

Secondary irrigation canal

(1) Increase of secondary irrigation canals from 28 nos, 34.6 km in total to 56 nos., 78 km in total including rehabilitation of the existing ones.

(2) Provision of OM cum farm roads for all the secondary irrigation canals together with laterite pavement of 20 cm thick and extension of the width to 3 m.

Main and secondary drainage canals

(1) Rehabilitation of the existing Tanima main drain of 7.2 km consisting mainly of enlargement of the cross-section and adjustment of the bottom elevation.

(2) Construction of Tanima catch drain along the new Tanima irrigation canal to intercept the runoff from the outside of the Project area.

(3) Increase of secondary drainage canals from 30 nos., 48.5 km in total to 53 nos., 79 km in total including rehabilitation of the existing ones.

Tertiary irrigation and drainage canals

(1) Rehabilitation of tertiary irrigation canals of 514 nos., 258 km long in total, consisting mostly in re-alignment and re-construction conforming to the proposed farm plot layout.

(2) Provision of tertiary drainage canals spaced alternately with the irrigation canals.

(3) Provision of OM cum farm roads along the whole tertiary irrigation canals with a width of 2 m.

Farm plot layout and land reclamation

(1) Standardization of the tertiary unit to about 6 ha (500 x 120 m), which consists of 5 plots of farmland each having a size of 1.2 ha (100 x 120 m).

(2) Land reclamation, consisting of clearing and rough levelling works, accompanying the standardization of the farm plot layout.

In the present stage, a thorough review is made on these previous proposals and it was found that there is no need of drastic changes from physical and engineering viewpoints, except for some modifications and revisions described hereunder.

4.5.2 Main irrigation canal

Modifications and revisions are needed for (i) the crossing structure at the Koba river, (ii) concrete lining works for the severe leakage portion, and (iii) treatment of the upstream 15 km of the canal.

(1) Crossing structure at the Koba river

The previous plan proposed to construct a long and massive masonry dike on the right bank of the canal and to evacuate floods mainly through the two spillways on the canal and one cross drain under the canal. Because of high construction cost and problems to construct such dike in low and marshy land, this plan is reconsidered and compared with a siphon method which is to pass the canal water under the riverbed.

The siphon method consists of (i) 3-barrels of corrugated steel pipes 91 m long and 2,000 mm dia., (ii) a submersible bridge of 65 m long and 5 m wide long on the left side of the siphon to pass the OM road along the main canal, (iii) embankment of the right bank of the canal of a length of 1,278 m and (iv) some river improvement works at the crossing point.

Comparison is made on these two alternatives and for the reasons mentioned below, the siphon plan is adopted finally.

- The siphon plan is far more cost-saving than the previous dike plan (US$ 663 thousand vs. US$ 1,123 thousand)

- The siphon plan has far better drainability of floods than the dike plan in that it can evacuate floods of any magnitude without adverse effects to the main canal.

- The dike plan has the demerit that about 250 ha of land become submerged during the rainy season.

- The dike plan involves several problems in operation and maintenance, among which the major ones are (i) it requires timely and smooth gate operation of the check structure to prevent floods from flowing downstream to the Baguineda canal and (ii) it may also require frequent removal of sediments which are brought into the canal by floods.

As the result of adoption of the siphon, it becomes impossible to make use of water of the Koba river for irrigation. However, it would

not cause any problem in the proposed irrigation plan because the Koba river scarcely keeps flow in the dry season, whereas water of the Niger river is estimated to be abundant enough to cover the whole irrigation area of the Project. As to excess water of the irrigation canal, it will be drained through tugs existing spillways located just upstream and downstream of the siphon.

(2) Concrete lining for severe leakage portion

The previous study compared five alternatives, that include (i) concrete-lining, (ii) rubber sheet, (iii) compacted earthfill, (iv) stone masonry and (v) corrugated steel pipes. It proposed the concrete-lining method as the most suited to the Project from viewpoints of water tightness, durability and availability of materials. In the present study, a comparative study was made to confirm the suitability of the previous proposal by adding one more alternative of "soil cement lining".

The result of the comparative studies is given in Table 4.2. It shows that the concrete lining method is the best-suited to the Project from the viewpoints of durability, physical stability, water tightness, availability of materials, practicability in construction, initial and operation and maintenance costs, etc.

It is to be noted that concerning this concrete lining method, the construction of under-drain is required to reduce the uplift pressure due to the prevailing high groundwater table.

(3) Treatment of the upstream 15 km of the Sotuba canal

The previous feasibility study does not propose any rehabilitation works for the upstream 15 km portion of the Sotuba canal, pointing out that water leakage in this portion is not as great as in the downstream portion of about 4 km. However, as a result of the present field reconnaissance on the upstream portion, it was found that considerable leakage is occuring because of lack of the right bank embankment at several places and deterioration of the existing bank. Rehabilitation works, consisting mainly of provision of the right banks and restoration

of the deteriorated bank, will have to be executed in this upstream portion.

4.5.3 Related structures to main irrigation canal

(1) Turnout

The existing turnouts are of the conventional sluice gate type and they are not provided with accurate discharge measuring devices. The previous feasibility study proposes only repair of the existing structures. In the present study, their entire replacement is proposed for the following reasons: (i) existing turnouts have deteriorated to a large extent and (ii) installation of water measuring devices is indispensable to prevent operation loss of water. For the selection of the most suitable type to the Project, comparative study is made on the following three alternatives (See Fig. 4.3).

Type A: Check cum Duckbill weir + Distributor
Type B: Aviogate + Distributor
Type C: Conventional type (Sluice gate + Discharge measuring weir)

Type A consists of severeal check cum Duckbill weirs across the main canal and a distributor at each turnout. It is intended that the water surface level of the main canal be kept constant by the check and Duckbill weir regardless of the discharge, and that diversion of water to secondary canal be made easily by the distributor in strict accordance with the irrigation water requirement. Type B consists of the Aviogate and distributor at each turnout. The Aviogate is a structure to keep the water level constant regardless of water level fluctuation in the main canal. The difference between Type A and Type B lies in that the former maintains the water level constant in the main canal, while the latter keeps the water level constant after diversion. Type C is of the conventional type which is to be provided with a

discharge measuring weir at the downstream end of the structure.

Based on the comparative study, Type A is adopted for the following reasons.

- It is the most cost-saving method , followed by Type C (Ref. Table 4.3).

- Operation is very easy because gate operation is needed only for the check gate and water diversion is controled easily by pulling-up or down the control panel of the distributor.

- Type B has almost the same advantage as Type A in respect of operation. However, because of very sophisticated mechanism, it may encounter with difficulties in maintenance especially in the availability of parts and technicians.

- Type C is quite familiar to the OM officials and inhabitants anywhere. However, it has disadvantages in that strict control of water diversion is very difficult requiring sensitive gate operation, and that it is apt to be fully opened through arbitrary operation by farmers.

The required number of turnouts will be increased from 49 in the previous study to 54 in total comprising 16 nos. in Sotuba, 26 in Baguineda and 12 in Tanima and Sienkoro.

(2) Check

In the previous feasibility study, installation of 4 check structures is proposed, however, due to the adoption of the above-mentioned Type A turnout, the number of necessary check structures is increased to 16 comprising 2 in Sotuba, 5 in Baguineda and 9 in Tanima and Sienkoro, respectively. The Duckbill type weir is to be adopted in 7 checks in the upstream, whereas the checks for Tanima and Sienkoro are proposed to be of the conventional sluice gate type.